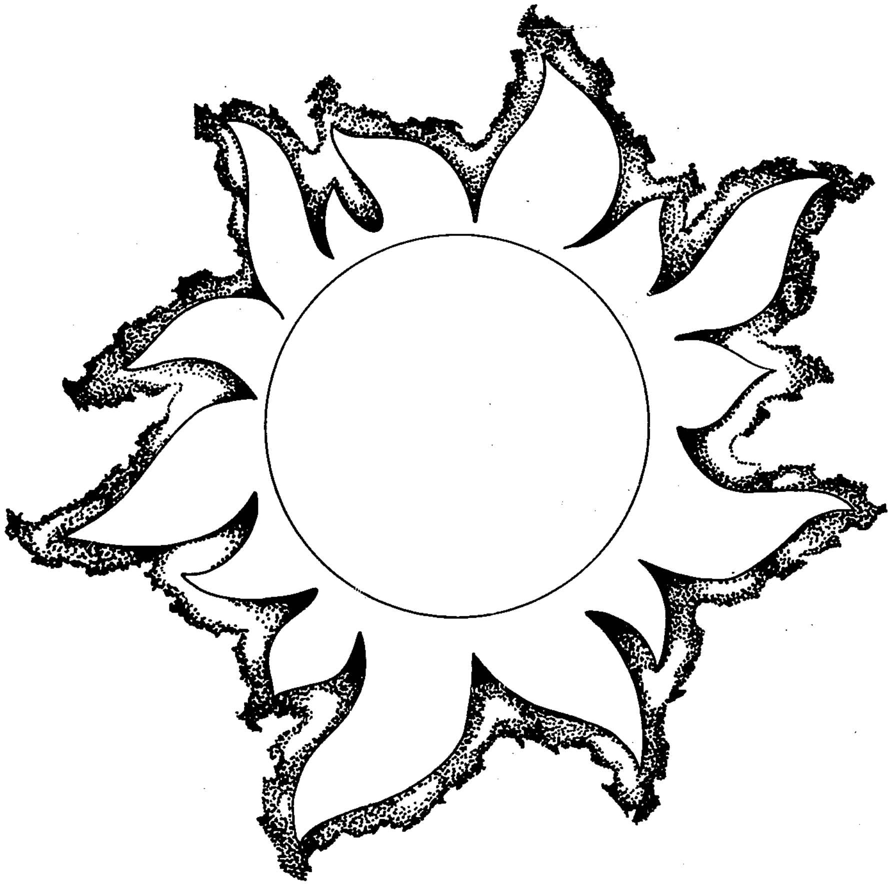
PROCEEDINGS

of the

Seminar on Energy Alternatives for Long Island



Sponsored by

The Regional Marine Resources Council of the

Nassau-Suffolk Regional Planning Board

May 13, 1974

Hauppauge, New York

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FOREWORD

Long Island holds a unique geographical position on the Atlantic seaboard of the northeastern United States. It is situated where the extreme southern boundary of the northern climatic flora and fauna meets the northern boundary of subtropical life. Northern lobster and cod join marlin and pompano in these waters, in the summer months. And northern spruce and birch mingle in the forests with southern long-leaf pine and azalea.

The island's coastline of nearly 1000 miles is indented with deep, rocky harbors and wide, marshy river mouths on its north shore; with shallow, tidal bays behind a barrier beach on its south shore.

The Regional Marine Resources Council was formed by the Nassau-Suffolk Regional Planning Board in 1966 to draw up guidelines for the protection of the region's unique marine environment and to develop a management plan for the wise use of these extensive marine resources. In its advisory capacity to the Planning Board, the Council completed, in 1973, a set of guidelines for Long Island Coastal management as models for local governments. They cover: Coast Stabilization and Protection; Dredging and Dredge Spoil Disposal: Wetlands Management; and Water Supply and Wastewater Disposal.

Even before the manifestation of the worldwide energy "crisis", the Council had given high priority on its 1974 schedule to an investigation into ways to decrease the impact of energy generation and use upon the Long Island marine environment. Starting from the promise that the world's supply of "burnable" fuels---coal, gas, oil, uranium---had finite limitations and also produced pollutants which are difficult, if not impossible, to totally manage, the Council planned to look into: 1) methods to decrease the need for plants using these fuels, and 2) alternative, non-polluting sources of energy.

This seminar on "Energy Alternatives for Long Island", which was enthusiastically sponsored by RAdm. Edward C. Stephan, Council Chairman, and Dr. Lee Koppelman, Nassau-Suffolk Regional Planning Board Executive Director, is the first step in this investigation. The speakers, who generously contributed their time and thought to the seminar, have presented practical answers which can turn the energy "crisis" into an energy "challenge".

Thanks are due to the Marine Resources Council Staff: DeWitt Davies and George Linzee for help in planning the program and for physical preparation of the Proceedings, Mrs. Eileen Retzger and Mrs. Mary Jane Korwan, as well as to Dr. Edith Tanenbaum, Nassau County Planning Board, who arranged the seminar luncheon.

Special thanks must go to the Nassau and Suffolk County officials who lent their support and presented papers showing the steps Nassau and Suffolk are already taking, and to the nationally-known energy experts who provided new solutions to energy problems to the invited Federal, state, and local planners and environmentalists. We hope these Proceedings will bring this important discussion to a wider audience.

May 1974

Ann Carl
Regional Marine Resources Council

OPENING REMARKS

RAdm. Edward C. Stephan, USN (ret)
Chairman, Regional Marine Resources Council

On behalf of the Nassau-Suffolk Regional Marine Resources Council, I welcome all who are attending this symposium. It is the sixth in a series of meetings which have been sponsored by the Marine Resources Council to look at problems of the marine environment that face Long Island.

In the past, we have had symposiums on shellfish culture, advanced wastewater treatment and disposal, wetlands management, dredging and coast protection, and oil spill prevention and clean-up. The idea of having today's energy crisis seminar was Mrs. Ann Carl's. She has made a great contribution in developing our program and organizing the speakers.

Throughout the work of the Nassau-Suffolk Regional Marine Resources Council, a major factor, perhaps the dominating factor, has been the interest and support of our elected officials, particularly Mr. Klein, the Suffolk County Executive. I would now like to present Mr. Klein, who will speak on the Suffolk County Energy Conservation Program.

SUFFOLK COUNTY ENERGY CONSERVATION PROGRAM

Hon. John V. N. Klein
Suffolk County Executive

Thank you, Admiral. Good morning, ladies and gentlemen. I am very pleased to take part in this discussion on energy alternatives and the more efficient use of energy for Long Island.

I am going to try to keep my remarks relatively brief and reserve the balance of the time here today to those who are experts in the field of energy conservation and alternatives to the consumption of energy as we now know it.

I would, also, like to extend a cordial welcome to all of the participants of today's meeting.

The Nassau-Suffolk Regional Planning Board's Marine Resources Council is to be commended for having arranged a seminar on this particular subject, and I am sure, after looking at the names of the people who are on the program today, you will have a very meaningful and provocative session.

Up until about a year ago, the word energy had no more than the normal meaning in my vocabulary. It was the stuff that propelled me from my bed in the morning and sent me through my day as Suffolk County Executive.

But for the last year, since the Federal Government dropped the energy crisis bombshell on us, no subject has been more on my desk and higher on my priority list of problems than this one. In fact, toward the latter part of last year, we were receiving so many calls and letters from residents during the gas and heating oil shortage, that I set up a Special Energy Crisis Coordinator's Office for Citizens requiring energy information or action, and they have called at the rate of five hundred a month. I assure you that our Energy Office is going to continue to function indefinitely.

I also assure you that in a County like ours, which is the fastest growing in

New York State, 86 miles long, with a million and a quarter residents, 680,000 registered motor vehicles and going up dramatically every year, and 11,000 employees of the County, alone, we lost no time in going into action on the subject of energy conservation.

Starting from the inside out, we issued a series of energy conserving directives to all 52 of our departments on a wide variety of matters. We ordered our employees to crack down on speeders exceeding the 55 miles an hour speed limit. We ordered thermostats in all County buildings lowered, ordered that hot water temperature and boiler temperature in all County buildings be cut down at least ten degrees. We asked that all hall and lobby lights be turned off during daylight hours. We asked maintenance men to turn off lights, office by office, each night. We directed all department heads to devise County employee car pooling schedules. We currently have two thousand two hundred employees involved in this method of getting to and from work. We, also, pressed County cars into service for pick-up of employees in the morning and return at night.

In addition to that, we appealed to our citizens and urged their cooperation on reducing the use of energy and I must say that they have responded beautifully. In fact, last September, Nassau County Executive Ralph Caso and I issued proclamations establishing a Nassau-Suffolk Energy Conservation Month. And neither of us have let up on that theme since.

In discussions with our Buildings & Grounds Department we have emphasized the importance of planning, energy-conserving architecture in the future. For example, designing insulation into buildings so as to conserve heat and allow it to be retained and recirculated. Setting up the means of recapturing heat, such as that generated by a data processing operation, so as to heat other parts of the building. Placing lighting controls in a central location so lights can easily be turned off. There is no longer any excuse for constructing buildings whose windows do not open, whose lighting systems are inefficient, or whose workers require the use of air-conditioning in summer for survival.

We have, also continually urged energy conservation measures for our citizens in their homes. I have called for a minimum standard to be set for efficiency in home heating installations and a County program of inspection of heating burner efficiency similar to the meter reading programs of the Suffolk County Water Authority.

I have expressed my views, too, to the Public Service Commission and to the Long Island Lighting Company on behalf of our heavily burdened, energy-consuming citizens. The Public Service Commission would do a great public service by requiring state utilities to change their rate structures. Currently the more electricity used, the lower the rates. Thus the biggest users of electricity pay at the lowest rates. In most parts of the country, electric use is about seventy per cent industrial and thirty per cent residential. Here on Long Island it is divided about fifty-fifty. A change in the rate structure to favor the small user would be a boon to the homeowner. I have also expressed my opposition to the practice of a utility like the Long Island Lighting Company conducting an advertising campaign promoting the sale of electrical energy at a time like this when we have low availability and high costs.

The automobile is one of our big energy bugaboos in Suffolk. Sprawled out over an area of 920 square miles, we are, most obviously, heavily dependent on cars. In fact literally the only means of transportation for ninety-eight per cent of the population of Suffolk County is the automobile, and 83 per cent of our working breadwinners rely solely and exclusively on private automobiles to get to their place of work. Naturally, this represents a large chunk of energy use. On a national level vehicles account for 24 per cent of energy consumption.

But our need is not for more roads. The answer lies in attractive, efficient commuter transportation on and off Long Island as well as within the bi-county area. Our mass transit should include a mix of commuter buses and trains, as well as large, high-speed ferries. While Suffolk is willing to plan and aid such facilities -- for example we pay operating and station maintenance subsidies to the Long Island Railroad now of 7.7 million dollars a year, approximately, and I have recommended an additional six million over three years for improving roadbeds in Suffolk -- no single municipality has the resources to effect such a sweeping mass transit plan. Massive Federal and State aid is imperative, and is a subject that we will be pursuing to the Executive and Legislative branches of the County Government in forthcoming months.

Also on the subject of cutting down on auto usage, I have recommended that study be given to requiring builders of large residential developments to provide, or arrange for, transportation to local shopping centers, and places of business. Conversely, requiring the builders of shopping centers to consider providing transportation to local communities.

Local governments have, for years, been calling for and making provision for the installation of roads, drainage, landscaping and part contributions from the developers to the Town or to the people of the community. It seems to me we are now at a point where the provision of transportation from a new residential subdivision on a continuing basis is no less an obligation which must be viewed assignable to the builder as that of putting in a street system, or a drainage system, or a part contribution.

We are constantly alert to energy-conserving methods and alternatives. We are currently watching with great interest studies now going on at Brookhaven National Laboratory on the subject of solar energy. Solar power has the advantage of not using fossil fuels that nature took millions of years to create. While not feasible yet on a large scale, solar power is becoming feasible for providing heating or cooling to individual homes. Even during a cold Long Island winter solar heating seems possible and we are watching technological progress in this development.

More esoteric forms of energy, such as large scale use of offshore windmills are now being studied by the Grumman Corporation.

Also, construction of Long Island Lighting Company's 800 megawatt nuclear power plant currently is underway in shoreham and the plant is expected to begin operation in the spring of 1977. The company has also applied for a permit to build two other nuclear plants. While I am admittedly a layman in terms of the scientific aspects it has become evident to me that the use of atomic energy for power generation, from an environmental standpoint, is significantly less offensive than the continued use of fossil fuels, particularly in view of the current legislation of the Long Island Lighting Company of converting one of its power stations from the consumption of fuel oil to coal.

One alternative to the energy shortage that neither County Executive Caso nor I will countenance is offshore drilling. I have continually expressed great sketpicism that offshore oil drilling could take place without irreparable harm to our ecology, economy and the way of life on Long Island. In fact the Federal Council on Environmental Quality confirmed in a 600 page report recently that oil drilling in waters just south of Long Island would be riskier than in most other areas in the Atlantic Ocean. Mr. Caso and I intend to rally every legal and scientific resource in the bi-county area in a coordinated fight against offshore drilling off our shores.

The battle for the conservation of energy will, in my opinion, go on into the foreseeable future. There is one happy note in our constant struggle to conserve it. Energy conservation is good environmental protection, too. Virtually anything that reduces energy use will result in a reduction ultimately of pollution.

I want to thank you very much for permitting me to speak to you briefly on this very important subject this morning, to give you a view of the concept we at the local level are dealing with in an effort to be responsive to the subject that has been raised by the Marine Resources Council, and that is alternative energy, rather than the traditional energy consumption. I am sure that the exchange of ideas that takes place will be of benefit in our endeavor to hold the line on the use of vitally needed energy and in finding other promising non-polluting sources of energy.

Again, thank you for the opportunity to be here and congratulations to the Council for organizing the forum and to you for participating in it.

Thank you very much.

NASSAU-SUFFOLK REGIONAL PLANNING BOARD MASS TRANSIT ALTERNATIVE

Arthur Kunz
Nassau-Suffolk Regional Planning Board

The basic concept of the Nassau-Suffolk Comprehensive Development Plan (Plan), as many of you know, is fondly called the "Three C's;" Corridors, Clusters, and Centers. We feel that this Three C's idea is one which will give us the possibility of a greater use of mass transportation if the concepts are followed over a period of years.

In 1970, when we completed the Plan, there was not as much interest in energy problems as there is today. We feel that there is a greater possibility of implementing the Corridors, Clusters, and Centers idea because of the energy crisis. I will briefly give you an idea of what is included and how we anticipated its relationship to mass transportation.

The Corridors concept relates to the idea of concentrating intensive uses in the central portions of Nassau and Suffolk counties. In other words, the greatest number of commercial areas, and especially our industrial complexes, should be concentrated in the central corridor where we have the Long Island Railroad and the Long Island Expressway. This is the main corridor in terms of mass transportation use.

You have, then, a large concentration of destinations, in terms of jobs in the central portion of the Island. You can see that this is slowly happening if you look between the New York City line out into Yaphank. Clusters of industry occur around Lake Success, the Syosset area, the Melville-Farmingdale area and Hauppauge, along the Expressway and the main line of the railroad.

By concentrating residential use on both sides of this central corridor, on the north and south shores, you end up with the possibility of people traveling to work only half the distance. In other words, if you live somewhere on the north shore and you work in the middle of the Island, you are going to go halfway across. If we have jobs spread all over the place, you could have the typical trip from the north shore to the south shore because the fellow who lives on the north shore would surely work on the south shore and vice versa. By concentrating most of the jobs in the center, we at least have the possibility of people making shorter trips to work, and if going to the same area, giving them the opportunity to use alternate means of transportation.

The Clusters concept is coming into existence now with condominiums, especially in the Town of Brookhaven, where we have large areas of clusters being built, yielding the same amount of people as our single family dwellings, but the units are in groups or clusters. These clusters, with a large amount of open space around them, at least encourage the possibility of bus service to the central portions of these new residential communities. Most of them are built with central recreation facilities, which makes it easy to bring one type of mass transportation - a small bus - into these areas to pick up people from a much greater population concentration than was ever before possible. If we continue this pattern of residential development, we will at least have more concentrated populations, with an opportunity to take people from the residential concentration to the job concentration.

The key to the whole idea is the last C, which I think is extremely important. That is the Centers idea, - concentrating major activities in group areas rather than spreading them out along the main highways.

The Plan emphasizes the concentration of a lot of our activities in the older business districts. Slowly, this is happening in places like Hempstead, where you have a lot of redevelopment, and you have a higher concentration of office jobs, activities and housing. We envision the same thing happening in places like Bay Shore, where we will be building a County Mini-Center to attract people in the area to patronize the businesses located there. If we follow this pattern of concentrating office buildings and commercial uses in new centers, we will have a much better opportunity for the use of mass transportation.

If you take areas around major shopping centers, in Nassau County, you see concentrations of office buildings occurring in a peripheral ring around the centers, such as Roosevelt Field. Where you have a large generator like that, it makes sense to add additional capacity in terms of offices to those areas, because the services are already there.

As far as new office buildings are concerned, many of them are locating in the older business areas. A recent Suffolk County Planning Department study indicated that there was great demand for additional office space. Some of this demand is starting to cluster in the business areas rather than along major roads. We must work in this direction, if we are ever going to increase mass transit possibilities.

Another portion of the Plan deals with the concept of transportation centers, and here is where I have a very negative response to report. Since 1970, when we completed all of the work and recommended transportation centers at various points along the main line of the Long Island Railroad, I can only say we have had total inaction. It is very, very unlikely that we will see this portion of the Plan implemented in the next few years, mainly because the State Transportation Bond Issue, which included these transportation centers, was defeated. Therefore, a very desirable location like Ronkonkoma for a major transportation center, a place where you can have large parking areas and a good bus inter-system, and a good electrified railroad system, will not be possible for a number of years.

I think it is important to note that during this winter of energy shortages, people were parking in every possible location in order to get to Ronkonkoma. In fact, the County is considering moving ahead with acquiring land for parking space just to accommodate all of the people that came to this station. I would like to feel that we projected the demand properly. The only trouble is that we did not meet the demand when it actually arose. I think we have to take measures to make sure this transportation facility becomes a reality. I don't know how it is going to happen without State money, but I have hopes that it will happen at this location.

In other areas, we recommended park and ride to encourage people to car pool, and we have designated a number of locations along the Long Island Expressway for such purposes. Little dots were shown in various places where there was land available at various interchanges. Now again, here is where the people are moving ahead implementing something that doesn't really exist. We have cars parked at most of the interchanges of the Long Island Expressway at the present time. We feel permanent facilities should be located here so that people will be encouraged to car pool. People have been discouraged in the past because it was, in some cases, illegal to park along some of the roads and, it is dangerous because of traffic conflicts. Such cars are also desirable targets for vandals or thieves during the day. Thus, people were discouraged from car pooling.

Bus transportation is the key to providing any type of mass transit within Nassau and Suffolk counties. The railroad is one thing, as far as travel to the City is concerned, but intra-county movements, are totally reliant on a bus system. Therefore, we are most disturbed to see that the peak for travel by bus was in 1948, and it has been going downhill since that time. We have found that the typical speed of buses in Nassau County was 10 to 12 miles per hour, and in Suffolk, about 20 miles per hour. One of the reasons for this is that the roads are way beyond design capacity. We need a combination of road improvements and more frequent service to encourage additional people to use buses.

In the last decade, as County Executive Klein pointed out, 83 per cent of the workers in Suffolk County used their car to go to work. In fact, that has gone up six per cent since 1960. In Nassau County, it is 71 per cent. It also went up eight per cent in the last decade. So, you can see that we are losing the war as far as trying to encourage people to make less use of their automobiles.

In the same period, between 1960 and 1970, the use of the Long Island Railroad declined by four per cent in Nassau and three per cent in Suffolk County. With all of our population growth, we have a figure of only four per cent using the bus going to work in Nassau County, and only one per cent using the bus to go to work in Suffolk County. We haven't changed that one bit. It has been stable for the last 20 years. So, I am sorry to say that this is an area where little change has occurred so far.

One of the factors that leads to the use of the automobile is our overall high income level and the large amount of car ownership. If you look at the car ownership figures, you realize we have quite an obstacle to overcome. Fifty per cent of the homeowners in this bi-county region have two or more cars already, and only seven per cent of all the households have no cars.

When you are working with numbers like these, you have to proceed with very desirable alternatives to attract people away from their private vehicles. Working for or against this, whichever way you want to look at it, of course, is overall density. In Nassau County, the density is only eight families per acre, and in Suffolk, it is only two. These are extremely low densities.

I am not advocating that we increase the density greatly. That would be self-defeating. However, the idea of concentration and clustering in the center of the Island is necessary in order to maintain an overall low density.

As far as the recommendations of the Plan relating to bus transportation, which is our main alternative, we recommended a grid plan that would establish a basic network of bus transportation through the Nassau-Suffolk region. Mainly, it would serve those areas that are high generators of traffic now, or that we anticipate will be high generators of traffic in the future. The anticipated factor is extremely important, because if you do not catch the typical rider or employee going to a new traffic generator, he is going to find other means, usually his automobile. He is going to buy that second car and you have lost him forever.

To give you an example, the IRS Center in Brookhaven immediately should have had bus service coming in from a couple of different directions. Then you can trap those people and get them dependent on the bus before they buy the second car.

The Plan recommended an initial bus subsidy of 3 million dollars in Nassau County and 2 million dollars in Suffolk to implement this bare bones network of bus transportation throughout the bi-county region. This recommendation aimed at providing service for the people who already need the service.

What has happened in Nassau County is now history. The bus systems became so poor that they are now in public ownership. Ultimately, the same type of thing may happen in Suffolk County. There are other recommendations for consolidation, - higher frequency and other services. Even with all of this, though, we took a very modest approach. We thought we could double the ridership in terms of the monies that were necessary to implement this basic network, because the basic network is designed to service a lot of people that do not have another way to get around. There are many people throughout the two county area that are totally dependent on something other than a car. This is why we felt it is very important to service this group.

Overall, this is an important reason for this subsidy, but at the same time we felt we could get a diversion of up to four or five per cent in the peak period. It sounds like a small figure again, but if you remove four or five per cent of the cars from our peak loads, we can diminish some of our demands for road widening and improvements, which are very, very costly.

These were some of the areas we have looked at in the Bi-County Plan. As you see, some of these things slowly get implemented if you are patient long enough, but in other areas I don't think we can be patient. I think we have to take some very positive action. I am hopeful that there will be money, especially from the State, to help us implement some of these ideas that we came up with more than four or five years ago.

DISCUSSION

QUESTION: Are there any incentives for a person to abandon his car and travel to work by bus?

MR. KUNZ: The only incentives now are economic incentives, with gas approaching 70 cents a gallon. The incentive there is to cut down on cost. Only time will tell whether a doubling in the price of gas will really make a difference. We really can't take advantage of the energy crisis. We do not have the ability to respond to a change. We couldn't respond rapidly at Ronkonkoma, for example. We just didn't have the capacity there. We didn't have the parking capacity, the bus network or the good service. We can only offer incentives if we have a better transportation network that can be run a lot more efficiently than it does now. It is possible to do this, but it takes government money.

QUESTION: Is there any study being made on the possibility of encouraging bicycle transportation for short runs to work?

MR. KUNZ: The Suffolk County Planning Commission has done an extensive study on an overall bicycle network for the County. In fact, they requested each of the towns and villages in Suffolk to respond to the County Executive, and tell him what they wanted to do as far as bike routes were concerned. The County will supply the money to implement a bike network. Such networks were oriented towards recreational areas, schools, etc. However, at the same time, there are business districts and other locations where there are people that can take advantage of bicycle paths.

QUESTION: Would it be feasible to have corridors for buses along the Long Island Expressway?

MR. KUNZ: It isn't at the present time. The Long Island Expressway is operating at double capacity. When you have 160,000 vehicles along an expressway which is only designed for 80,000 vehicles, you can't even take one lane out without having a disaster area. You can't do it without coming up with an alternative of more capacity at the onset.

In Chicago, for example, the trains go through the middle of the expressway. As you are sitting on the train you see bumper to bumper traffic. This encourages you to ride the train. However, you couldn't take a lane away at the present time on the basis of what we know in terms of the total traffic volume. If there is reconstruction, though, an exclusive bus lane could be constructed. This was done on Interstate 95 leading into Washington from the Virginia suburbs. This works because it was built into the project. It works in the Queens Midtown Tunnel in the morning because you have a low flow of traffic in the reverse direction.

If you look at the traffic on the Expressway, you see that there is also a large reverse flow of traffic from the City to the suburbs. This doesn't give us the alternative of using the City to suburb lanes, because no off-peak exists.

QUESTION: What is the status of a Long Island Sound bridge?

MR. KUNZ: We have always had a lukewarm response from Connecticut regarding such a bridge. I understand that the Mayor of New Haven is not hostile to the idea of a Wading River crossing into New Haven. The Tri-State Regional Planning Commission is currently studying this and I expect a report early next year. It may well recommend that this service be instituted.

QUESTION: Have you considered the possibility of centralizing the location of a ferry crossing, say, from Lloyd's Neck to Stamford, Connecticut?

MR. KUNZ: The Wading River crossing is not so much central as it is accessible. There is only one north-south highway that goes from shore to shore, and that is the William Floyd Parkway, and it is a multi-purpose road. You can have a ferry terminal at Wading River without touching one home. It is an immediate construction possibility.

Further west, for example, at Port Jefferson, you could never expand the possibilities because you are so constrained by the street system, and the harbor and so forth. At Orient Point, you are too far away.

QUESTION: Has anyone looked into the possibility of utilizing school buses for additional mass transportation? School hours in a particular area, say Ronkonkoma, could be altered so that school buses could be used to take people to the train during rush hour, and then be used to take the children to school. The buses would then be used to take the children home after school, and then to pick up the workers at the evening rush hour.

MR. KUNZ: This was discussed and there is one drawback to it, and that's in the morning rush hour. No matter how you work with the school program, their buses run from an early morning hour to a mid morning hour because the same buses are used for the secondary schools and the kindergartens, along with special services and so on, so that they overlap the entire morning rush hour. This has been the problem with that type of use. I don't say it is impossible, but there is a conflict in the morning hours.

ENERGY CONSERVATION IN EXISTING BUILDINGS

John Mockovciak, Jr.
Grumman Aerospace Corporation

For the past four years, Grumman has addressed much of its attention to the nation's energy problem. Results of our investigations concurred with others in both government and industry that United States power demands can be expected to double every eight years, and that demand will continue to grow for electrical power, in particular....Unless appropriate measures are instituted to modify the continued growth in energy demand.

Recent governmental actions and energy research and development budget proposals, however, appear to place major emphasis upon satisfying the projected long-term demand. There appears to be very little real emphasis, budgetary or otherwise, directed towards reducing the projected energy demand levels.

Conservation and more efficient use of available energy sources can have an effective significance upon both near-term and future energy demand. That is the subject that I intend to address; namely, Energy Conservation, Right Now!

Many people ask us "how come" Grumman is in this energy area. This is, to some extent, in response to the question: "You fellows can get to the moon and back, why can't you do all these other great things to help solve our problems here on the ground?" Thus, over a period of four years, Grumman has been trying to apply aerospace technology to people's problems on the ground, today. By and large, we have been targeting the energy problem.

Let's take a look at the "energy problem". The National Petroleum Council made a two year study for the Department of the Interior, and it represents one of the most extensive studies of our nation's energy problems, to date. The projections indicate an increase in coal usage, and certainly an increase in the use of nuclear power. Domestic gas production will be on a decline. Domestic oil production is expected to remain about constant, but the major and most dominant factor in those projections is the tremendous rise in oil imports between now and 1985.

For some time, we at Grumman have felt that something has to be done to turn these energy projections around. We are convinced that about the only thing that can be done in very near-term is to look towards energy conservation.

When I use the term "energy conservation", I mean more efficient use of the energy sources that we have available to us now.

So far as energy conservation is concerned, many people don't realize that it is a fundamental philosophy in the aerospace business. Those of us in the aerospace industry eat, sleep, live and breathe energy conservation in all of the kinds of systems that we design and build, whether they are aircraft or spacecraft. More recently we have been trying to apply this inherent philosophy toward high energy consuming sectors, beginning with buildings.

At Grumman we have combined our analytical-aerospace skills together with our in-house architectural and engineering skills to work on energy conservation in buildings. Our in-house architectural and engineering skills represent the equivalent of a one hundred man architectural and engineering team which, in the A/E business, represents a rather large firm.

The importance of buildings in the overall energy problem can be appreciated by understanding how energy is used in this country. About 40 per cent of our energy is spent in the industrial sector, about 25 per cent in the transportation sector and about one-third in the residential and commercial areas. Of the one-third in the residential/commercial areas, about 16 per cent is heating and cooling alone. When heating and cooling are accounted for in the industrial sector, heating and cooling alone represent about 25 per cent of our total national energy budget.

Therefore, buildings do represent a very significant energy expenditure area.

We started our energy conservation activities at Grumman on a pilot plant, an Engineering Office Building called Plant 25. This building is a three-story, 225 thousand square foot facility that houses our principal space programs engineering staff. We found that in August of 1971 (in the middle of summer) the plant burned 16,000 gallons of fuel oil. Those of us who initiated the work on this particular building sort of scratched our heads and said, "How can we be burning 16,000 gallons of fuel?" Very simply, in asking this question, it put us on the trail to the energy conservation answers.

As we began to look for answers, we found that not only did we burn 16,000 gallons of fuel oil in the middle of summer, but essentially we burned the same amount of oil, every month, all year round. Electric consumption, however, generally peaked in the summer months because of the higher air conditioning load.

Plant 25 is rather typical of office buildings in that the core of the building is serviced by a central air handling system, and the outside of the building by a perimeter air handling system. The purpose of the perimeter system is to handle the varying skin loads around the outside of the building, and to provide for individual comfort conditions in offices that are generally located in these areas.

The operation of the central air handling system is worthy of note. Comfort conditions in the "conditioned" space are maintained by a room temperature thermostat. Air that has been heated rises into a plenum (ceiling) duct and is collected. Part of this warm air is exhausted, and the balance returned, via a by-pass duct, into the primary conditioning duct. This return air is supplemented with 15-25% of outside air, and the combined air mixture passes thru a cooling coil that drops the air temperature down to about 55 degrees Fahrenheit. The intent here is to get the humidity out of combined air mixture down to acceptable conditions. Next, the air mixture passes through a heating coil raising its temperature to what the room temperature thermostat is calling for. What actually goes on here is a cycle, wherein air which has been heated once, comes around through a primary conditioning duct, is dropped in temperature and then reheated again.

This type of a system is called a dew-point reheat system, and represents a type of heating, ventilating and air conditioning (HVAC) system that exists today in many buildings. This type of system could be called "a big dumb system", in that it is a simple mechanical system to operate and maintain. It has proved very reliable in the past, and has found broad acceptance in the building industry.

By and large, HVAC systems have been selected to provide for building load conditions that exist for either a low temperature extreme or high temperature extreme. In our area, the low temperature extreme is zero degrees Fahrenheit; the high temperature extreme is 95 degrees Fahrenheit. The HVAC system in Plant 25, more or less, provided a constant cooling capacity across the high-low temperature spectrum. This cooling capacity represented a considerable excess in the median temperature range (40-70°F outside temperatures) where we spend most of the time. That excess cooling capacity, then, had to be supplemented by an additional heat source....the oil burner.

As regards the number of days per year that we spend at different temperature levels here on Long Island, we spend most of our time around the 40 degree temperature region and in the warmer portion of the year around the 70 to 75 degree temperature region. These regions also represent where most of our energy was expended. Most of our oil expenditure in Plant 25 had been about the 40 degree temperature reading and the major electric expenditure around the 70 or 75 degree temperature reading.

We have also performed electrical consumption analyses on this building. The largest part of the load is lighting, next come cooling pumps, and air supply fans, both of which are part of the HVAC system, and finally such things as elevators, et cetera (which are pretty much lost in "the noise").

We have also performed analyses relative to the subject of lighting. Our analyses indicate that when you take into account relamping costs, labor costs, and the cost of electricity,...the longer you leave the lights off, the more energy and the more money you save. Obviously, if your turn a switch on and off continuously, you will be burning out that bulb much sooner. But, we found that if you leave the lights off for, like, more than 20 minutes to a half hour, it pays. Energywise and costwise, it pays.

Now, where has all this led us? Our initial work on Plant 25 suggested ways of reducing our oil consumption by better than 70 per cent. Electrical savings could offer a reduction in demand of about 50 per cent. In terms of costs, we are projecting reducing our operating costs for this particular building, thru energy conservation, by better than 50 per cent.

The message is very clear, saving energy saves money.

As a consequence of the success that we saw in this one particular building, the Grumman management encouraged us to institute a full scale energy conservation program at Grumman's facilities. Analyses of nine of the first 30 to 35 buildings that we have tackled (at this point in time) indicate a substantial reduction in oil usage potential across a spectrum of buildings ranging from office buildings to factories to laboratories. The average reduction in oil use is expected to be about 40 per cent, and represents a million gallons a year of oil....enough to fuel 600 homes on Long Island.

Electric reductions in these plants are expected to be about 16 million kilowatt hours, annually. This represents an oil savings in terms of LILCO of about another 600 homes.

We have also been performing energy conservation services for a number of government and commercial clients. For the National Aeronautics and Space Administration, we surveyed two sites, one in Langley Field, Virginia and the other in the Lewis Research Center in Cleveland, Ohio. The two sites, basically, have the same floor space and, more or less, perform the same type of research activities. We found that the energy conservation potential at one site was considerably larger than the other. This brings up another very interesting point, and that is.... that no two buildings are really alike, and what you can do in one building, you cannot necessarily do to another.

In fact, the types of energy savings that I am discussing here do not come about from merely turning off lights and reducing thermostat settings. Rather it comes about through detailed analyses that find where the energy "bodies are buried" and developing appropriate modifications for the operation of heating, ventilating and air conditioning systems.

The key point is that each building is like an individual. They are all different, and if I were to tell you what we did in one building, you might misinterpret that it could be done in yours.

We are also doing energy conservation services for a number of school districts here on Long Island. In one senior high school, for example, the energy-saving system that has now been installed has reduced their oil expenditure by 50 per cent.

Energy conservation takes a bit of organization, particularly in a large corporation. You cannot treat this subject in a haphazard fashion. You need a dedicated team, and in our particular case, we've brought together the skills of both aerospace and facilities people to make an organized effort at reducing energy expenditure in our plant facilities. I must emphasize that you cannot go about doing this unless you are organized and committed.

In addition, our in-house energy conservation program involves considerable public relations activities. It includes such things as displays and posters in plant lobbies and flags identifying plants that have been put into an energy conservation mode (a take-off on the old World War II Army-Navy "E"). Where we have made specific installations of new equipment, these are also identified. We also have identification stickers on lighting panels to encourage people to turn the lights off when no longer necessary.

We have also provided a specific form of identification for our plant maintenance people. When they are out doing an energy conservation job in our plants, people can see who these people are and identify that the activity is, in fact, for the purpose of energy conservation.

Our corporate vehicles are also identified with bumper stickers and all of the mailings going out of Grumman have a postmark encouraging energy savings. Also, from time to time, news articles appear in our in-house newspaper, called "Plane News".

To meet today's energy problem, we feel,...is through energy conservation.

A key aspect, however, that we have found lacking in both our own facilities, as well as other types of building facilities we have looked at, is a lack of sufficient metering to control energy expenditure. We foresee, in the future, much more emphasis in this particular direction.

Now let's ask ourselves, "Will all this energy conservation really help the oil problem that we identified initially?" A study done by the Office of Emergency Preparedness, (an arm of the Executive Office of the President) titled "The Potential For Energy Conservation" indicated that the more emphasis you put on energy conservation, the more of a slice you can take out of the projected import energy demand.

For example, in 1980, if there were a concerted effort toward energy conservation, this study projected that we could cut our import requirement on the order of 50 per cent.

Let me leave you with this final message. There is something that can be done about our energy problem...and it is something that can be done now. It is called ENERGY CONSERVATION.

DISCUSSION

QUESTION: I may have missed something, but the only term I heard you mention was the production costs. What about capital costs?

MOCKOVCIAK: As I indicated, what we do in buildings is much more than just turn out and remove the light bulbs. When we go into a building, we, first of all, look at how it is being used and the function it is supposed to perform. Then we look at the building's heating, ventilating and air conditioning system, and determine how that building is being operated to satisfy the needs of the people that use it. If necessary, we configure appropriate feedback control systems, to modify the operations of the building to reduce energy expenditure.

So far as capital expenses are concerned, we use a term called "pay-back". What we are trying to do is to recover the expenses of equipment and labor through energy savings,...and by and large, we are able to see recoveries (pay-back) within one year.

QUESTION: You mentioned turning off the lights would save money, but you make no mention of the type of lighting, whether incandescent of fluorescent. Is there a significant difference?

MOCKOVCIAK: There is a tremendous difference between fluorescent and incandescent. If you have incandescent, I would say go to fluorescent, number one. It will cut your energy expenditure considerably, at least in half; but whether it is incandescent of fluorescent, the same holds true... turn the lights off!

QUESTION: Grumman is to be congratulated on the extensive technical study of its systems, but I believe you haven't touched on a system which is very pertinent to this, and that's the incentive system. You indicated that you saved 40 per cent in energy. However, the energy producing corporations have asked our controlling commissions to increase the price of electricity by 25 per cent. When this hits the average homeowner who is bending over backwards to try to conserve energy, and then he finds out that when he cuts down the amount of energy used, and finds out he still has to pay the same price for less energy, there is no incentive and he says to himself, "What am I saving?"

MOCKOVCIAK: I agree with your feeling that there really is very little incentive, but from a standpoint of a large concern, because of the rising price of energy, it is just good business to start doing this and save energy in order to save money. But you are absolutely right, there are very little, if any legislative incentives to save energy. I don't see the mechanism in being yet, that really can bring about large energy savings. As I remarked when I started my discussion, there seems to be a major emphasis toward incentives to provide more energy sources, but there doesn't seem to be very much incentive to reduce the demand.

What I hope that I have illustrated here is that we can reduce the demand. We, at Grumman, are going out and doing it, and we are doing it right now. Many people, I guess, look to the aerospace people as sort of being out in the clouds...that they make things happen in maybe five or 10 years,....but we are doing it right now. We think that a very concerted effort in energy conservation can bring down energy demands considerably, and I wholeheartedly agree with you, there are positive legislative incentives that ought to be considered both from an individual homeowner's standpoint as well as from a corporation standpoint.

QUESTION: I want to ask you and the other panelists a question as to goals in energy growth. What do you see as the ultimate goal? Is it a zero growth, is it just lower growth in energy consumption, and what do you see as the technical limits that can be achieved using some of the techniques that you have talked about here today?

MOCKOVCIAK: First of all, it is difficult for me to project on what energy demands will be in the future. All I can "lean-on" are past historical records which show a direct relationship between economic growth and energy demand. I don't know if the economic picture in the future can change that. But what it sort of says is that in order to improve the way we live, it looks like we will end up using more energy, not only as a country, but on a per capita basis. I think, really, that it is on a per capita basis where the problem lies. Many of us, as individuals, use quite a bit of energy. But, even in this country there are people who are not economically well off and who want to be as well off as we are. In order to be as well off, they are going to be using more energy on a per capita basis. So, in substance, I don't see, really, any way of reducing the growth in energy demand to a zero growth level. That, I think, answers one part of your question.

I do see, however, that since there does not appear to be a way to bring energy demands down to a zero growth level, that also says that we are going to have to bring new energy sources on line.

Energy conservation gives us the time to bring new energy sources on line, new clean environmentally acceptable energy sources. Energy Conservation will buy us time.

MESSING: I think that within a 10 to 15 to, perhaps, a 30 year period, we are going to have to seriously consider an energy plateau in this country, and that will depend on net energy calculations and on new energy analyses in terms of how much energy is actually available to us. The concept of net energy is one that has been developed recently, and I think it would affect the amount of energy to be used in the future.

The other brief comment I would add is that I think the trend in the future, which has been mentioned, toward gross national product or per capita income, wealth and energy has been based on the availability of low cost fuels, which in an era of increased technological trends is diminishing, and I think that would again underscore the need for energy conservation.

I think there is a possiblity of a no growth energy time; I think that is possible and, maybe necessary, and will depend on new data that's being developed now.

QUESTION: Have you changed the basic heating and cooling system of your building? In other words, are you using the basic process that's there now?

MOCKOVCIAK: Yes. Fundamentally, we have not changed what's in the building. We have principally modified the operation of the system through a reconfiguration of the controls and operation of the HVAC systems.

ENERGY CONSERVATION IN HOUSING

Donald Watson
Yale School of Architecture

I would like to discuss ways of reducing the heating and cooling requirements in buildings by designs that recognize natural climate impact. The designs illustrate principles that are simple enough to apply as rules of thumb whether you are sitting on a building committee or designing your own house. (See Figure 1.)

We have just heard mentioned a useful concept -- the net energy cost of a product. I would like to introduce another concept which is the basic principle that an architect or engineer would use in order to assess additional construction that would save money over a long period of time. This is called life cycle costing.

For example, an additional 500 dollars worth of insulation could save more than that amount over five years of operation and is thereby justified as a life cycle economy. It is this type of costing we are now introducing into design decisions.

Buildings ought to be built for a life of at least 50 years, yet we cannot predict what sources of energy we will have in 50 years. This raises another concern: that is, the equipment we install now may have to be refitted or replaced, depending on the future energy sources.

The slides I will be showing demonstrate energy conservation in experimental houses. Architects are able to experiment with houses more than other buildings. The design principles, of course, would apply to larger buildings.

The first slide is a list of some of the possible housing patterns that we might see as energy conservation becomes more important. Whether one is involved in an urban, suburban, or even rural area, energy conservation will have an impact on the way the housing is planned and developed. In existing urban areas housing stock may be structurally fit, but in terms of heating and cooling, it might need

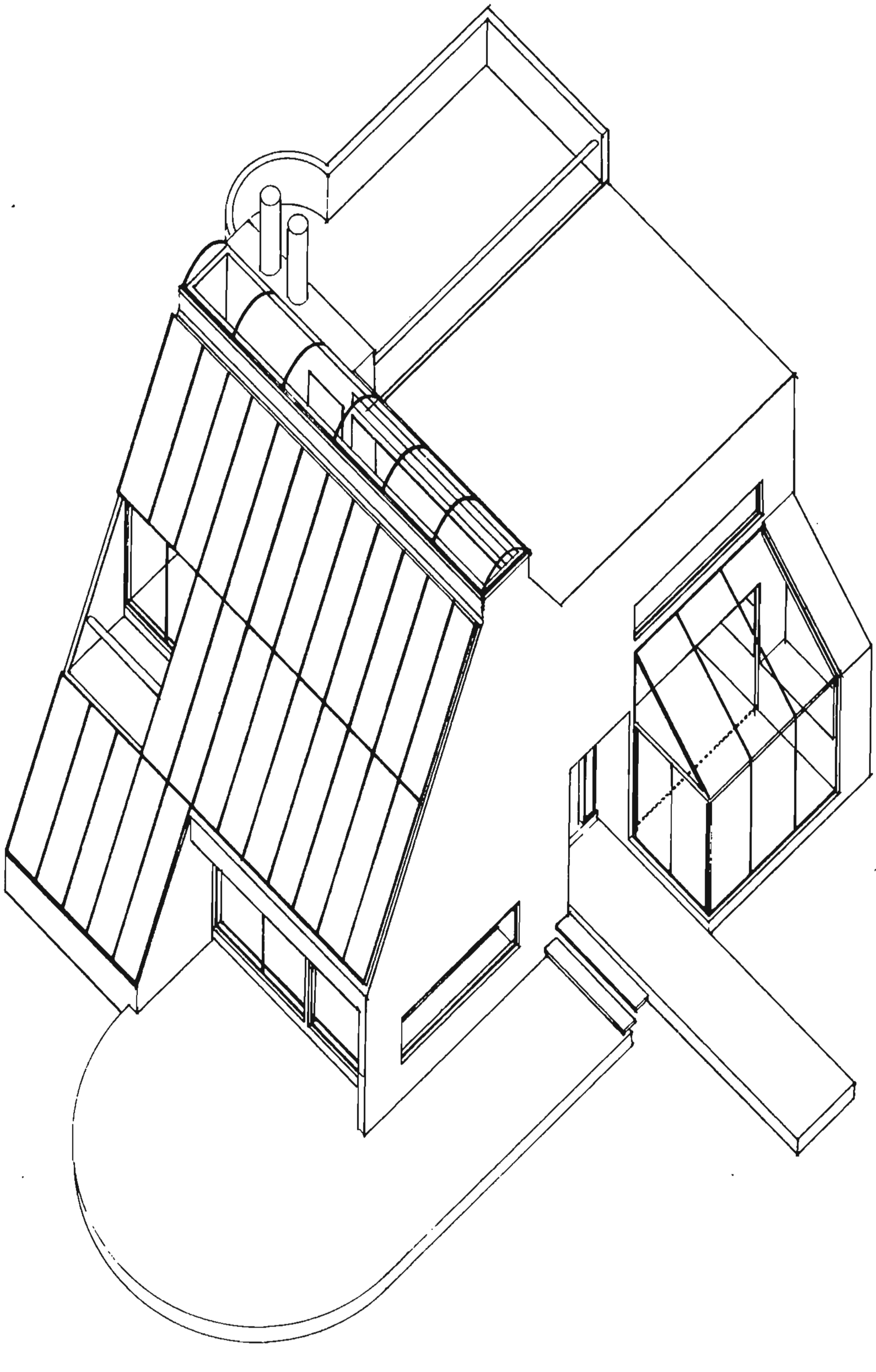

Figure 1. An alternative house form for flat-plate solar collectors to provide partial or complete solar heating.

to be refitted, with more efficient mechanical equipment, or reinsulated to higher standards. Thus, rehabilitation of urban structures will be more attractive, because in cities we have existing transportation networks that can be used at lower costs than the car transportation mode on which the suburbs depend.

One program already exists for fixing up urban houses: the Federal Housing Program called "urban homesteading". This is a way of rehabilitating existing houses by selling them at low cost to families who agree to do the reconstruction and to live in the units themselves.

In the case of new housing there will be increased reason for clustered or row house arrangements. Also, transportation needs to be energy efficient: pedestrian and bike networks for trips to school, shopping and even to work.

In the case of the suburban housing built very rapidly after the war, perhaps at a sacrifice of construction and insulation standards, there may also be a need for attention to correct heat losses through air infiltration and through windows and doors that are not insulated or protected by storm windows. So, refitting and rehabilitation of existing suburban structures might increase more than new house construction.

Within the suburban or rural situation, there may be increased emphasis on what we will be discussing below as energy independence; perhaps through increased use of residential windmills or solar panels. Even today, solar heating for domestic hot water is competitive with electric resistance heating. You may pay for the additional costs for solar heating equipment by fuel savings in three to five years.

The second slide is a diagram that shows in outline what I will discuss. Listed across the top are the climatic impacts to which housing or any buildings are exposed: (1) Thermal impact is exposure of the building to the radiation heat of the sun and sky. One wants to increase the thermal gain in winter, and minimize it in summer; (2) The impact of direct sunlight. Obviously direct sun in summer increases the heat load on a building, particularly if it passes through glass windows. In winter, the same heat is welcomed; (3) Wind and air flow. In winter, wind on the building chills it, but in summer, the wind is a source of cooling by natural ventilation.

Those are the three climatic factors that I will now discuss.

The next slide is a map of Connecticut shown to illustrate an important point. The degree days are shown for the different parts of the state. Note the tremendous difference in the resulting heating requirements of a building between a location on the shore and one inland, for example, near Hartford. There is a 15 per cent degree day difference within an hour's drive. In terms of heating requirements, this would amount to about a 70 dollar heating bill difference, between two identical houses. Thus, depending on the place and location of the building, insulation standards and climatic design vary greatly.

Slide four is a chart that shows the thermal impact of solar and sky radiation on a building. It shows a three dimensional cube, or building, and the heat gained by the various building surfaces depending upon their orientation. One of the important points made by such analysis is that the south wall of a building in the temperate zone in January is exposed to up to twice the amount of heat gain as the horizontal roof, and up to 1.8 times the amount gained by the same wall surface during summer (when the sun is higher). Thus if one wishes to place a window for maximum winter heat, the southern orientation is ideal.

The same diagram also shows the amount of solar heat gained on the north side. Thus, a window on the north side of the building is a potential heat loser 24 hours a day during winter. Very little sun ever reaches that surface when it would be desired.

The next two slides illustrate some farm buildings, just to show how these lessons were once very well known as rules of thumb. First, a building in Denmark with the openings, the windows and doors, on the south side. The roof was designed for snow build-up during the winter, so that the snow would act as an insulator. The next slide shows a structure in Switzerland with identical design principals. Slide 7 is a thermal analysis of a skyscraper in model form, and illustrates a rather sophisticated way of studying the impact of the sun on a particular building configuration. What is seen most readily is the heat gain by a particular orientation at different times of day. In this case, not only is the heat built up by direct solar exposure, but also by reflections of adjacent surfaces of glass one into the other, which increases the heat load for small areas within that particular configuration, and causes, as you perhaps know if you work in office buildings, the uncomfortable imbalance between hot and cold areas on the same floor.

We will see how lessons of thermal impact analysis apply later in specific designs.

To introduce the subject of wind design, is this slide of a village wherein the farm buildings are protected from winter winds by high hedges that are at times three stories high. Wind effects on buildings have been completely researched, in this example, from Texas A&M Research Station (slide 10).

The effect on natural ventilation through different window designs is shown in this example. Building models were placed in a wind tunnel and smoke traces followed the effect of air flow in and around different building shapes and openings. These studies were neglected for the last 15 years as air conditioning was available to solve any cooling problems and, in fact, office buildings frequently were built with windows that cannot be opened. Now, natural ventilation is once again important in design.

The next slide shows an interesting exercise that demonstrates some of the principles of air flow. Looking at the two diagrammatic plans, one poses the question: If you had two windows, a large one and a small one, and wished to place them so as to maximize the cooling effect of natural ventilation, where would you put them on the building? Would you place the large opening on the windward side and the small on the opposite lee side, or would you do the reverse?

As it turns out, even though one might at first think to put the large window to windward as if to capture more wind, it is the opposite positioning that gives the better result. The small window on the windward side increases the velocity of the air at the intake and, therefore, increases the cooling effect. (See Figure 2.) This, and perhaps a dozen other basic principles of air flow, can now be applied to design. In the design of the sizes and location of windows, these air flow principles become critical once again.

The next slide sequence shows sun control devices. This first type of sun shade is placed on the exterior where it is most effective in reducing heat gain. Once the sun hits glass, the heat gets into the building interior even though one may have draperies. The basic principle of reducing the heat load during the summer is to keep the sun off glass by some sun shading or awning devices.

This slide shows examples of buildings where their overall form is determined by a concern for sun protection. In the first case, the building's facade is angled inward so the sun does not hit the glass directly. In the second example, each succeeding floor overhangs the windows below. If you like angles in buildings, you have your excuse now.

The next slide shows an analysis of window location for natural daylight. How does one place a given window size, in order to maximize the amount of light? The slide shows three alternatives. The traditional design, on the lower left, locates the window in the middle of the wall. Such a location is apt to create glare between opening and wall, usually so bothersome that one needs curtains which in turn reduce the natural illumination. By placing the window along a wall, as shown in the right bottom, the wall is used as a reflective surface. One can demonstrate this effect

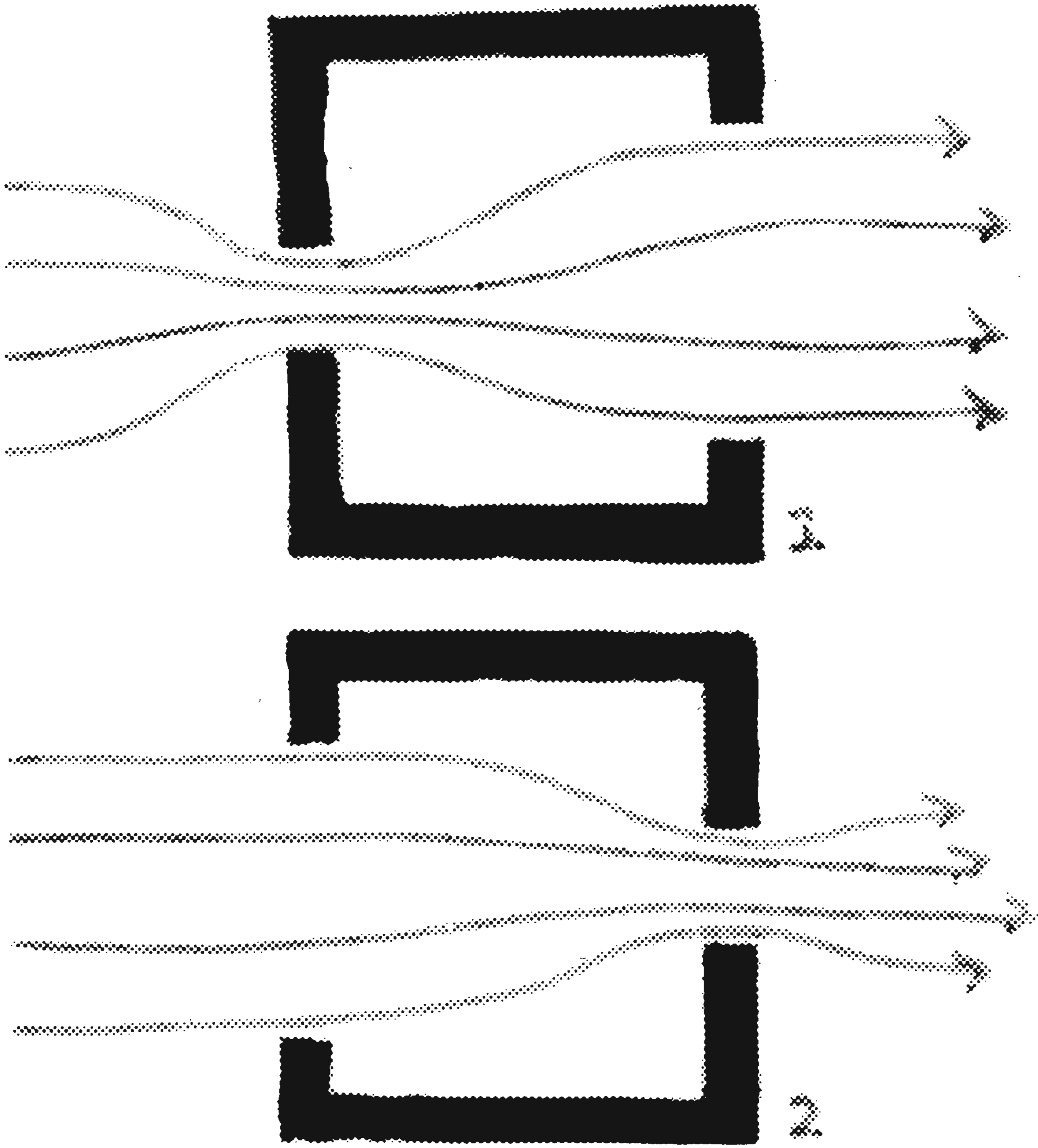

Figure 2. Two alternative arrangements for air inlets and outlets.

with a light bulb just to see the increase in illumination gained by the use of reflective surfaces, particularly if they are lightly painted.

The third alternative may be the best. A window across the top of the wall is particularly suitable in a classroom situation, if the ceiling is a reflective surface, and a reflector is placed outside and at the bottom of the window. The other advantage of high window placement is that it gets light further into the room.

The next slides illustrate examples of natural lighting studies in architectural models, in this case, a study of natural light obtained through an interior light well. Assuming the well is the only lighting source one sees from the two slides, there is a considerable increase gained by proper location of reflective surfaces. This effect could be achieved in this example by a reflecting pool at the bottom of the light well.

Here are some examples of combining the principles of thermal, light and wind considerations. Underground housing: This is a slide of troglodyte desert housing in North Africa, looking into a large open area which is about two stories deep, open to the sky and from which radiates a series of caves. When the temperature at the surface is 125 degrees in the cave it may be only 75 to 80 degrees and quite comfortable; in the deepest caves it may even be chilly. Why? The effect of the earth above provides thermal insulation which has, in effect, a six-month time delay. During winter one obtains heat from the soil above.

Here, in the next slide is a recent house built on Cape Cod and placed underground around an atrium that is open to the sky.

The next slide is a very elegant example of underground massing by building into an existing orchard terrace.

And a final example in this series is a school partially underground, open on one side to the south, with sod roofs for additional insulation.

The following slides show fireplaces as a heating source. The first is the design of Count Rumford, perhaps the inventor of a shallow fireplace, the type that is so shallow that you would think the fire would get into the room. He found that the plan of fireplaces in Colonial times was essentially square. He studied the radiation effect of fire into the room and argued for the type of plan with splayed walls which better reflects the heat into the next room.

This phenomenon is clearer in the next slide of the fireplace cross section. What is known now as a smoke shelf can be attributed to Count Rumford. He reasoned that the hot air from the fire goes directly up the interior face of the flue up the chimney. The smoke shelf is added so that cool drafts are encouraged down the chimney and then bounced up it to implement an excellent draft within the narrow neck of the fireplace. Even in the Rumford fireplaces a good deal of heat goes up the chimney.

The next slide is a design of a Swedish ceramic oven. One fire a day will keep this ceramic oven warm for 24 hours; the oven then radiates the heat into the room. The heat that normally is lost up the chimney here is captured by an extended flue, much like a maze, where it is drawn into the bricks.

The next example shows other basic design applications. The first shows a house called Sunnycave in North Carolina heated only by a stove. (See Figure 3.) The owner reports that early morning temperatures in the winter never get below 60 degrees and in the summer, when the temperature in North Carolina is 90, the temperatures in the house never rise above 75 degrees. Why is this? You see that the greater part of the house is protected by earth berms that are built up against the walls so that the earth acts as insulation.

The internal winter air flow shown by the arrows is also of interest. The cold air from the wall surfaces drops down the walls and drains through cold air drainage slots at the bottom of the floor. From under the floor, it goes into the basement, obtaining some moderating heat from the earth, being about six feet below

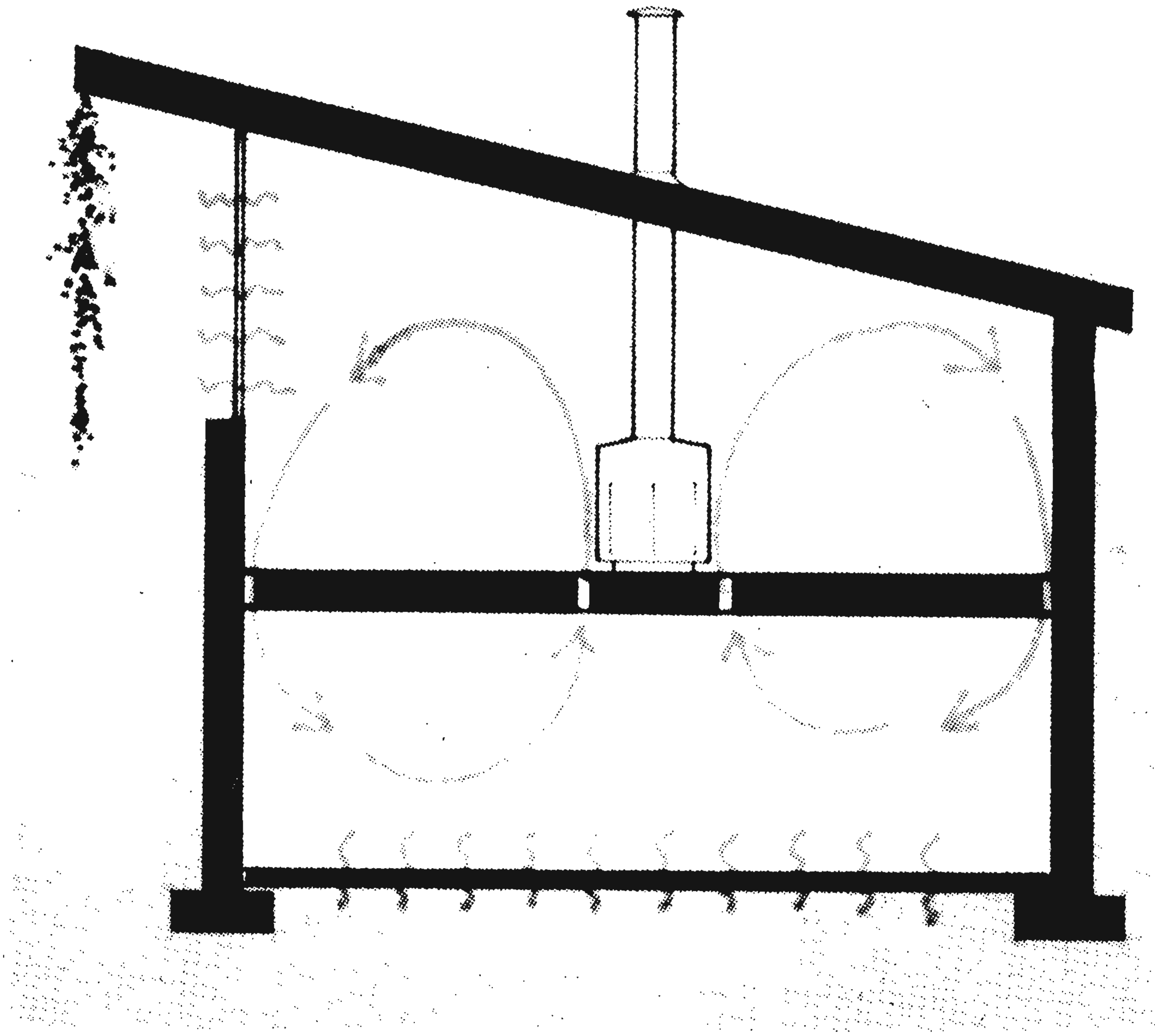

Figure 3. Design of a house in North Carolina reportedly maintains temperatures that do not exceed 75 degrees in summer or fall below 60 degrees in winter, with only a small stove as the heating element.

the earth. From the basement the air is drawn up once more through the center of the house where it is fully warmed at the stove. Additional heat is gained from the south-facing window.

A second example that combines energy conserving principles is shown in Figure 4. A sun monitor was added to the roof of an existing two story suburban house for natural illumination, and it also provides winter heat gain from the sun. A translucent insulating panel on the interior is opened, when one desires heat or air to be admitted. An interesting example of what one can do with existing windows is shown here as an insulating shutter on the inside. In the 1950's, windows facing the south were known as "solar windows". Manufacturers were claiming they were a source of heat. However, if they are not insulated from the inside, they were a net loss, if one calculates the heat gained and lost in the 24 hour period. But if one adds insulating panels (one or two inch rigid insulation, covered with fabric) the result is a heat trap which can be used very effectively. Without such a provision for insulation, windows lose from 5 to 10 times the amount of heat that is lost by an insulated wall.

This discussion has been intended as an introduction to the opportunities and problems of solar heating. This last slide shows three or four designs all of the same basic house, but with varying amounts of solar panels to provide, in the first case, hot water heating only, and, in the other cases, up to total space heating as well.

In the last case, one senses that there is too much roof area devoted to the required solar panels. This is one of the design problems of using solar heating with the current state-of-technology.

Everett Barber will now continue and show how we combined these principles in some projects that are presently being built in Connecticut.

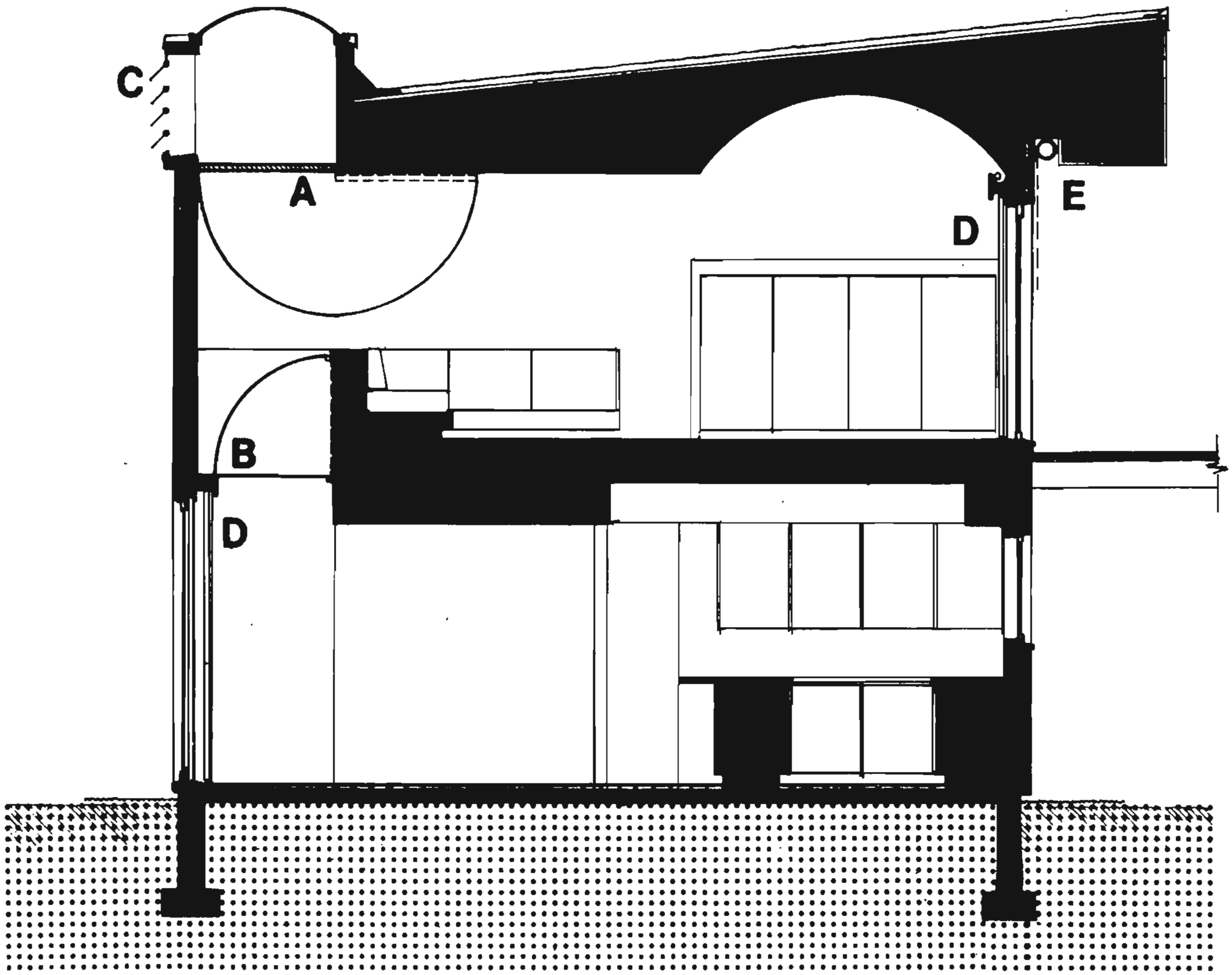

Figure 4. Cross-section of a house alteration designed for energy conservation.

USE OF SOLAR HEATING AND COOLING

Everett Barber
Yale School of Architecture

One of the things I have noticed when Don and I have spoken to groups in the past has been that when the subject of energy conservation comes up, there does not seem to be nearly so much interest in it as there is in solar heating. I find that a problem when I deal with people who say they are interested in solar energy because they expect that solar panels, windmills or some other 'climate' form of energy will be the answer for all their energy problems. I can't emphasize this point enough. In no way will solar energy become economical without severe energy conservation measures such as were talked about by the gentleman from Grumman, and those principles demonstrated by Don Watson.

I heard this calculation: If you take a plane area, three feet by three feet and point the normal to the plane at the sun from about nine a.m. until three p.m., there is a constant source of heat striking that plane, on the order of one kilowatt, which is quite a bit of energy. If you envision that amount of energy striking an area equal to that of New York City, you may have the impression that a great deal of energy strikes New York. However, more energy is lost from the buildings in New York City on a day in winter than is received from the sun on a clear day. It seems to me there is a lot of room for energy conservation before we consider solar heating.

I will show some slides that depict the designs of existing solar heated houses. There are probably 20 or 30 of them that have been built in the United States. I will then show the house that Don designed in Connecticut, and that I did the solar heating system for, and then show a house that attempts to integrate all the features; that is, solar heating, wind electricity and energy conserving schemes.

This is a house which was designed a while ago; you might get some idea of just how long ago if you look at the rear end of the car in the garage. It was done in 1948 by someone in the School of Architecture at the University of Minnesota. The point to note here is that solar heating has been around for quite a while. There has been a fascination with free heat for a long time.

The first documented solar heated house in the United States was built at M.I.T. in 1939. Since then, M.I.T. has built four solar heated houses and generated a good deal of information in this field. A number of universities, including the University of Minnesota, have been involved in the study of solar heating for houses.

This is a sketch of a solar heated house that illustrates another principle. The solar heat collectors can be placed on a vertical wall as well as on an inclined surface, and there are some advantages in doing this. If you don't need much heat during the summer, then the vertical panels provide the heat during the winter when the sun is low on the horizon. In the summer, when the sun is high, very little of the collector is exposed to the sun, thus the build-up of unwanted heat can be avoided.

This is an illustration of a house with the panels on a vertical wall, and they are, in this instance, placed on a fence. I see this as being one of the most practical ways of providing solar space heating for existing houses. I am involved quite a bit with solar space heating right now, and there seems to be a number of people interested in augmenting the heating systems in their houses with solar energy.

This is a house that was actually built in Dover, Massachusetts in 1949. I think the house was financed by Mrs. Peabody, and Mrs. Raymond was the architect. Dr. Maria Telkes was the system designer. The collectors are on a vertical wall above the first floor. The house is almost totally solar heated. One of the things that you may notice here, which Don has alluded to, is the dominance of the collectors in the image of the house. You can, by insulating the house better and taking into consideration some of the principles that he has reviewed, perhaps reduce that dominance of the form of the building somewhat.

This was a house built in 1956 at Lexington, Mass. It was the fourth and last of the M.I.T. solar houses. It had 1,700 square feet of heated floor space and about 800 square feet of collector. It was instrumented and its performance analyzed for about three years. If you are interested in references, you can write the Department of Chemical Engineering at M.I.T. and ask for some of the references on their solar work. They charge a very nominal fee. And the references are excellent!

This is a view of the collector on a house in Washington, D.C. The house was built by Harry Thomason. Thomason has been building solar houses in Washington since 1956 or a bit earlier. He has built about four of them. Unlike the M.I.T. solar houses which are no longer solar heated, all of the solar heating systems of Thomason are working.

The M.I.T. houses had their solar heating houses disconnected, because the professors didn't see themselves as plumbers and didn't want to be responsible for constant maintenance of the heating system. The Thomason houses have been working for as much as 10 or 15 years. His collector, for example, is very much simpler than the M.I.T. collectors. It is simply a single sheet of glass with black and corrugated metal beneath. At the ridge pole of the house is a perforated pipe. Water is pumped through the pipe, leaks out through the perforations and then trickles down the grooves. It is an extremely simple design.

One point before we go on. This rather effectively emphasized energy conservation. The floor area of this house by Thomason is something like 800 or 900 square feet, and I understand the collected area in this house is something like 1,200 square feet. You can imagine the extent to which so much collector must dominate the design of the building.

This is Thomason's present house. The collectors are fairly obvious in the inclined plane. I am not quite sure of the percentage of solar heating. You usually find that most of the solar heated buildings that are constructed are not totally solar heated, the one in Massachusetts being an exception and another in New Mexico being the only other exception in that they were totally solar heated. The economics of total solar heating are such that the amount of collectors and storage doesn't justify complete solar heating. It is simply less expensive in the long run to use 75 to 85 per cent solar heating than to use 100 per cent solar heating.

Incidentally, Thomason has a pool that is solar heated too. It is inside the little room to the left of the picture. This slide perhaps, shows the collectors more clearly. There is a single glass cover sheet and, then, the blackened galvanized steel below. You can just see the water going down the troughs of the corrugations. It is not a terribly efficient collector, but it is inexpensive.

This is a house that was built in Boulder, Colorado. It is owned by one of the old-guard energy engineers, Dr. George Lof. It is about a 3,600 square foot house. The solar heating system provides about 35 per cent of the total house heating requirements annually.

When you say a house is, say, 50 per cent solar heated, that doesn't mean that the auxiliary heating system has to be 50 per cent of the total heating system capacity. Rather, the auxiliary heater has to be sized to handle the total capacity of the house. The percentage is expressed as a portion of the annual energy requirements.

These are the collectors on this house. They are a different design than the ones you have seen before. They use air as the heat exchange medium rather than a liquid.

The problem of heat storage has been a considerable one. Thomason uses water. The M.I.T. houses all used water. Lof uses rock in the systems he has designed. It takes about two and a half times the volume of rock to conserve the same amount of heat that can be stored in a given volume of water. In this instance Löf used the cylindrical forms used in concrete construction and filled them with rocks. These forms go from the basement floor to the top of the second floor. During the daytime, when the sun is heating the collectors, hot air is taken from the collectors and then pumped into one of the storage cylinders. Air is taken of the other cylinder as needed to heat the house. When that cylinder is exhausted, the operation is reversed and the house is heated from the other cylinder.

This was a photograph from a recent issue of Popular Science. They showed a photograph of some of Farber's work at the University of Florida. Farber has been working on solar energy for about 15 years or more. Among other things he has developed air conditioning systems that are solar powered. He also provides domestic water heating and space heating from those collectors. He has a house that is totally solar powered; that is, the electrical requirements as well as the thermal requirements are provided by solar energy.

About a year ago, Don Watson came to me and asked if I would be interested in working with him on a solar heated house to be built along the Connecticut shoreline. I was quite eager to do that.

Once we had convinced the clients this was the way to heat a house we began in earnest. Don asked me what my requirements were; that is, the collector areas that I thought I would need, and the volume needed for heat storage and the type of distribution system. I gave them to him and then didn't hear from him for a while. Finally he came back to me with the drawings and I found that about half the collectors I thought I needed had been provided. He was limited in this area by a zoning height limitation of 20 feet, and by the owners requirement that they have a lot of glass in the south wall of the house. Then he had to use multiple rows of collectors.

We have about 400 square feet of collectors installed now. I would prefer to have more like 800 but then you can see the constraints under which Don was working.

This is a cutaway view of the house. The beige is the first floor, the salmon colored area is a half flight up and, then, there is another floor above that. The house fronts on Long Island Sound. It is a very lovely setting and I think Don has done an excellent job in integrating the collectors within the house. It was no easy job.

This is a schematic design through the house which shows you the three rows of collectors, one behind the other. Here again, you have special constraints in collector spacing. The rows of collectors are spaced so that the the winter sun hits the entire collectors in rows behind the first row. If the collectors were, let's say, half as far apart as they are now, the rear collectors would be partially in shadow.

These are just a few slides showing installation of the collectors. We installed the collectors on the house in February. The collectors are panels that are six feet long. They become the exterior of the roof. They are insulated and they have a sheet that carries the water through the collectors.

This rigid piece of metal heats the glass sheet. It is the sheet that gets hot and it has tubes going through the ridges that carry either water or an antifreeze. There are pipes that run across those rows at the top and at the bottom that carry the supply and return water.

One question I have been asked is what happens when it snows? There were about four inches of snow on the roof and the ground due to a snowfall the night prior to the taking of this picture, and when we arrived at the house, the collectors were pretty well covered. This was about 9:15 a.m. In about 20 minutes, all the snow was off the collectors. All it needed was for the black to warm up to above the melting point, and the snow then began to slide off.

The next house integrates many sources of solar energy; it is going to be built, hopefully, later this month for my wife and me in Guilford, Connecticut. I didn't design it. I had a fistful of schemes on ways to conserve energy, and I went to an architect, Charles Moore, and asked him if he could design the house in an economical way. He did a lovely job of integrating all these schemes in a house. I will go through it.

The overhang that Don talked about lets in the sun in the wintertime, and keeps the hot summer sun off the house during the summertime. The building construction is masonry; that is, concrete blocks with three inches of insulation on the outside of the blocks, which saves on insulation on the inside of the masonry. It gives you a more even temperature inside, and it tends to store heat that gets inside the house better than where the thermal mass on the outside of the house is subject to all the exterior temperature extremes, like cold winds, and so forth.

You can get a lot of light into the interior part of the house if you do it right and not pay a large price as far as heat loss through glass is concerned. We were surprised to see the amount of light that can be piped down a vertical shaft that is painted white on the inside. The ratio is, say, 10 to one, which gives a high amount of illumination at the bottom of such a shaft. The solar panels, as you can see, are on the outside.

The house faces southwest. There are louvers in the belvedere at the top. They allow the wind to blow through and draw air out of the house. They also let the stack effect of the house work. In the throat of the belvedere are fine pipes that are connected to the heat collectors. During the summer I am going to have a lot more heat than I will know what to do with, as I don't plan to use absorption cooling, because it is close to Long Island Sound and I don't think I will need it there. In order to and heats the glass, and the snow slides off and cleans the windows.

The choice of plastic has been worked with by a lot of the people. Most plastics do cloud. The ones that don't have problems. They melt and sag at high temperatures. If they don't have that problem, they don't give you the greenhouse effect that glass does. That is, they have a very high transmittance of sunlight in, but they also allow a lot of heat to get back out.

QUESTION: Over what period of time does it take to reduce transmittance?

MR. BARBER: The Bureau of Standards tests have not listed any reduction. One per cent reduction in transmittance is due to the airborne dust. In the M.I.T. tests that were done on collectors where they were concerned about the dirt build up -- in other words, they wouldn't wash it off, they would let the normal rain clean it -- there was about a four per cent reduction.

They are very much in favor of using central collection and storage facilities in developments. I think that was pretty well illustrated by at least a half a dozen projects that I know of going on in the United States that involve communities of anywhere from 20 houses up to 400 or 500. There is one such project in Vermont. The engineer on that is Fred Dubin from New York, and he has written a good deal about it already.

GASOLINE CONSERVATION IN AUTOMOBILES

Marc Messing
Environmental Policy Center, Washington, D.C.

I would like to address the problem of energy conservation in automobiles from a slightly different aspect than I originally had intended. It has become clear from the previous presentations that technological progress is not necessarily dependent upon the emergence of new technologies. In other words, we can make considerable technological progress through better utilization of technologies already available to us.

Before I get into the question of automobile energy conservation, there is one concept that I would like to introduce, because it has not gotten enough public attention. It has been developed relatively recently and is going to be important to the ongoing resolution of our energy problems. This is the concept of net energy.

Several years ago when the term energy conservation was being introduced in public discussions, some people asked, "Do you mean you are going to have to do with less energy?"

As one speaker mentioned early this morning, energy conservation does not necessarily mean doing with less. It means getting a greater efficiency from the energy available to us. Perhaps, the best illustration of the concept of net energy this past winter is long gasoline lines. As anybody who experienced them for an hour or more, soon realized in looking for gasoline stations that were open, and sitting in lines with engines idling, it took energy to get energy. Often one spent more energy looking than one got in return when the gasoline was finally recovered. Precisely the same thing is true of the exploration for oil, or the development of any new high-technology energy source. Technologically, it takes energy to get energy, and unless you are very careful, you expend more energy looking than you ultimately find and recover.

There are two immediate implications to this: first, it is going to be more expensive to get additional energy resources; second, it is going to require more energy to get these new energy reources.

For example, to drill offshore for oil is more costly and more energy intensive than to drill onshore. To search for oil in the Arctic or Alaska is more expensive than to drill in Louisiana or Texas. Like the Second Law of Thermodynamics, to which it is closely related, this might be stated as the Second Law of Energy Exploration: It takes energy to get energy. And the farther away the source, the more complex the technology and the higher the cost of adequately protecting the public and the environment, the more it is going to cost.

Calculations of the net energy efficiency of nuclear fission indicates that it may produce a net gain of as little as 3%, and recent calculations on the Liquid Metal Fast Breeder Reactor program suggest that it may ultimately consume more energy than it produces.

With fading low cost petroleum fuels, within an economic situation which is changing radically, the concept of net energy is quickly becoming a critical factor in our public policy determinations. In an energy crisis which is first and foremost a petroleum crisis, we are dependent for 96% of our national transportation energy budget on petroleum. Also, we find that the private automobile consumes approximately 55% of this energy resource (trucks consumed 21% and aircraft 7 1/2% in 1972). Finally, in examing net energy relationships, we find that the increasing costs of energy production, in conjunction with decreasing net energy gains further flames our inflationary spiral. If it costs more money to develop a given amount of energy, then your BTU per dollar is decreasing, resulting in an inflationary trend. Therefore, I think our energy crisis is very severe and is getting worse.

Now, looking at the potential for energy conservation in automobiles, we can distinguish three separate levels on which the automobile operates where there are potentials for energy conservation. The three levels are: 1) transportation systems, in which the planning of total transportation systems can reflect on the energy consumption of automobiles; 2) the market and industrial level, on which decisions to produce certain types of vehicles rather than others impact directly on the total energy consumption levels of the automobiles; and 3) the consumer level, where there are several opportunities for consumers to improve the gasoline consumption of their own automobiles. Roughly speaking, these three levels are listed in the order of their potential for the greatest long-range energy savings, and are listed inversely to the immediacy with which these savings can be realized. In other words, where we have the greatest potential for significant automobile related energy conservation in the development of improved transportation systems, it will take us the longest time to see these benefits; where we have the best opportunity for immediate savings, on the consumer level, the potentials for significant conservation are the smallest.

Other factors which will affect the decisions that are made in regard to all these areas include: questions of petroleum supplies and gasoline availability; materials availability and costs for such materials as steel, copper, bauxite and other related industrial materials; the enforcement of transportation emission control systems to meet the standards of the Clean Air Act; land use constraints; and the economics of transition as we move from the historical growth-based economy toward the alternative of a steady-state economy. In one way or another, all these factors are likely to affect the decisions we make regarding energy savings and the automobile.

In 1899, Scientific American noted that, "The improvement on city conditions by the general adoption of the motor car can hardly be overestimated. Streets---clean, dustless, and odorless---with light rubber-tired vehicles moving swiftly and noiselessly over their smooth expanse would eliminate a greater part of the nervous distraction, and strain of modern metropolitan life." But today, Congress still clings to that 19th century dream. The automobile has so choked New York City that traffic today moves more slowly than it did 70 years ago, and the effects of the automobile on air pollution, public health, noise levels, and the "strain of modern metropolitan life" have been well documented.

The Clean Air Act has provided for transportation control systems to abate unhealthy air quality levels, and, contrary to misconceptions of Congress, this is entirely consistent with increased energy conservation savings. In 1972, the Office of Emergency Preparedness listed the "shift to inter-city freight from highway to rail, inter-city passengers from air to ground travel, and urban passengers from automobiles to mass transit" as among the most significant realizable measures to affect (energy) conservation". The director of the Federal Energy Office, Office of Energy Conservation, Transportation Division, has written, "For IC (inter-city) traffic, autos are less than one-half as efficient as busses, but more than twice as efficient as airplanes. For urban travel, mass transit is more than twice as efficient as autos. Human transport (bicycles and walking are 10-40 times as efficient as motorized transport." I might also mention here, in response to a question raised earlier, that the first gravel road in the U.S. was constructed around 1845-50 in Pennsylvania, and the impetus for additional gravel roads came around 1870-80 following the introduction of the bicycle, or the pedocycle as it was called then.

The point, however, is that though we have the greatest potential for energy conservation in the remodeling of our urban national transportation systems, the savings are not immediately available. It takes time to build transportation systems, it takes time to replace automobile traffic with rail service, and it will take time to realize the long-range net energy benefits that would accrue from better rail and mass transportation systems.

The second area of potential energy savings is in what I have called the market/industrial area -- options which could be provided to the consumer. Such options include the choices between bigger cars and smaller cars, bigger engines or smaller engines, more efficient or less efficient energy systems, safety options, comfort options, etc. I will talk briefly about this point now and then return to the subject from a historical perspective.

The average mileage of American cars has been in the area of 13.5 to 14.5 miles per gallon for the past 20 years, and these figures reflect certain dominant patterns in cars manufactured and purchased in the United States. The average weight of these cars has been over 3,000 pounds (and increasing), the average engine size has been over 300 cubic inches (and increasing), and the preponderance of all private cars purchased in the United States has been powered by a reciprocating internal combustion engine. As one analyst has noted, "despite an improvement in fuel economy for a 6 cylinder auto since 1940, the fuel consumption per mile has tended to remain about constant. Today, higher speeds on turnpikes and increased urban congestion have served to hold down on otherwise better potential energy efficiencies." This same observer has noted that "By 1980, a compact inter-city auto with only 5-8% better all around energy performance might get about 28 mpg if held to 50 mph or 25 mpg at 55...if engines remain in the 30% thermal efficiency (range). Barring a breakthrough in small turbines, or 6 cylinder technology, this remains the upper limit for speeds in the 50-60 mph range. The major options available to the industry turn on the thermal efficiency range of the internal combustion engine. Other engines do exist, have been marketed in the past, and could be produced by the industry today if there were felt to be sufficiently economic incentive to warrant the production. In fact, pre-chamber diesel engines, stirling cycle engines, and rankine cycle engines, are all used in vehicles that are on the road today, and provide higher road thermal efficiencies and better fuel economies than the current conventional internal combustion engines. Despite other attractive qualities, the Mazda rotary engine ranks lower in terms of thermal efficiency.

Generally speaking, there are about a dozen major factors which influence vehicle mileage and which are determined somewhere between the corporate planning room and the consumer's garage; these include the engine efficiency and displacement, compression ratios, torque conversion, the transmission ratios, axel ratio, aerodynamic drag, tires, accessories, vehicle size and weight, and emission control devices.

I have been amused, on the one hand, by oil company ads this winter, indicating the potential for savings when driving 50 mph rather than 70, because at the same time, the same oil companies have been reluctant to advocate construction of cars designed for driving 50 mph instead of 120, 130 or 150 mph, (speeds that are not permissible anywhere in the United States).

What the oil companies were advocating -- let me backtrack one or two years -- provoked a significant case for the Federal Communications Commission (FCC). Several years ago, ads on television promoted large cars with large displacement, high octane engines. A case was brought before the FCC claiming this was controversial because large cars that required large displacement and high octane gasoline, required more energy than smaller cars. The case was argued successfully. Now that oil companies are faced with imminent petroleum shortages, they are not advocating that people buy small cars, but that they use large cars and drive them at 50 mph.

Gasoline consumption depends on a variety of factors. The principal factors are the size of the vehicle, the weight of the vehicle, the size of the engine or the horsepower output, and then accessories.

As I have already noted, the fuel consumption per vehicle mile has remained essentially constant since 1940, which tends to suggest either a stagnant technology, or some other factors (which have already been mentioned). In other indices of automobile energy consumption, we see that the total energy efficiency of the automobile, or the net energy efficiency has been declining. For example, from 1925 through 1941, the average life span of cars increased consistantly from 6.5 years to 10.2 years, and in 1956 the average life span was 11.1 years; it has deteriorated since then. Total accumulated mileage over this same period increased from 25,000 miles per car to 104,000 miles per car in 1956. Though, in 1970, the mining industry was boasting that the average American sedan represented 13 tons of mining productivity, the energy crisis has focused new attention on some of the inter-relationships. While it has been estimated that "between 1890 and 1970 energy intensiveness defined as BTU per mile increased by 12% (i.e., automobile efficiency declined 11%)", and other researchers have estimated that "recycling car hulls can reduce the energy requirement to manufacture automobiles by a maximum of 38 million BTU (30% of the energy now required)" and have calculated that "the energy cost for manufacturing autos would be reduced by 62% on a per vehicle mile basis" if the life span was tripled and additional energy requirements increased by 15%.

As for accessories, as a rule of thumb, any power accessories, including power brakes, power steering, power windows, and especially automatic transmissions and air conditioning units, increase gasoline consumption. In 1957, 84% of the cars sold in America came equipped with factory installed automatic transmissions, and by 1971 that figure has increased to 90.2%. Only 5.4% of the cars came with three speed transmissions in 1971 and 4.4% came with four speed transmissions. Similarly 42% of the cars purchased in 1957 came with power brakes; by 1971 this figure increased to 59.3%. However, the most dramatic increase was in the number of factory installed air conditioning units, which were not available in 1957, and which came on 84% of the cars purchased in 1971. It is these buying habits, in conjunction with the increased size, weight, and engine capacities of the automobiles manufactured and sold in America today that offer the greatest potential for energy conservation, while completely new transportation systems, less dependent on the private automobile, are developed.

To return to some of the more basic attributes of the car and its design, the fuel consumption characteristics of the car are related to the size and shape of the frontal area. Aerodynamically streamlined design may have some effect on fuel economy, but bigger cars (frontal area) have more air resistance and get lower fuel economy.

Any way you cut it, the size of your car is your key consideration in terms of energy conservation. The larger car, even at 50 mph, still consumes approximately twice as much gasoline as a car half the size and half the weight. Therefore, to advocate driving cars that are designed to be driven at 120 mph or faster, with a weight of 4-5000 pounds or more, and that have high acceleration characteristics for the purpose of effecting energy conservation, is unnecessary, undesirable, and absurd. We should remember that we are talking about cars which require 13 tons of mining productivity (at a time when many of the materials in question are in short supply), which use high energy intensive processes in their manufacture, and which require substantial energy requirements for standard use and maintenance, at a time when inflationary spirals are effecting all of their related costs (and the cars are being designed for values directly contrary to our national goals of energy conservation and energy independence).

This is not to say that energy is not conserved in standard sized American cars by driving slower rather than faster at highway speeds: but it should be noted, and should be emphasized, that those same cars could drive faster, rather than slower, with greater fuel economy, if the engine sizes and acceleration characteristics were reduced. Lighter weight European imports with small displacement engines provide one example of this. The average American car produced today puts out 300-400 horsepower, and even the smallest compact produced comes with engines virtually twice the size of full-size European family sedans and race cars. The added power contributes preponderantly toward acceleration characteristics and is achieved at the cost of fuel economy. The difference here is that if a 5000 pound car can get 13 miles to a gallon at 50 mph, then a car half the weight and with half the engine size can get twice the mileage at the same driving speed.

I would like to discuss briefly some of the historical aspects of the development of the automobile. If we look back to the history of the automobile, we find there were various options available to the automotive industry at various times. One of the first automotive vehicles was produced around 1779, in France. It had three wheels and a steam engine. This was a wood boiler affair. The manufacturers claimed it had a top speed of two and a half mph, but one very serious problem was that it had to stop for refueling every hundred feet or so. There were steam operated motor vehicles in the 18th century. A variety of steam vehicles were built in the 19th century, principally in England, between 1800 and 1831, when Parliament effectively outlawed them. This was accomplished through taxes and strict safety requirements. The owners found requirements like red flags by day and red lanterns at night objectionable, and by 1831, the steam vehicle was essentially phased out in England.

Toward the end of the century, the laws were rescinded and steam vehicles were produced. At the end of the 19th century (1885) the first reciprocating internal combustion engine, which is the generic name for engines found in hundreds of passenger cars today, was built by Gottleib Daimler.

The year 1894 saw the invention of the first petroleum fuel car, and in the early 20th century the automotive giants, whose names we now associate with the cars we see on the road -- Ford, Mercedes, Renault, and Porsche -- were experimenting with a variety of different vehicle designs. There were electric cars on the road, steam vehicles, diesel vehicles, and external combustion engines, as well as internal combustion engines.

Incidentally, contrary to the pronouncements of the TVA and the advertisements of The American Electric Power Corporation and many other private utility companies, it is nonsense to think that electricity is a solution to any of the energy related problems we faced this past winter. To return to the concept of net energy again, it takes energy to make energy, and the production of electricity requires the burning of some other fuel -- at a thermal efficiency of 25-40%. Electric cars may be the answer to some of our urban air pollution problems but the production of electricity, as everyone here knows very well, is environmentally costly, -- the burning of some other fuels is no solution to these transportation problems.

As late as 1927, the world land speed record was held by a Stanley Steamer with an approximate speed of about 110 mph. The question is then raised, "Why have we developed an automotive industry which is based exclusively on one type of engine which is not necessarily the most efficient type of engine?"

The problem with the steam engine is two-fold. First, it took 40-45 seconds for the car to build up a head of steam, and the boiler, itself, was a very heavy and cumbersome unit. The people with diesel engines today find a similar problem. The fact that it takes three to five seconds for a diesel engine to warm up is considered a market liability.

The second part of the problem with steam engines is that they did have a tendency to explode, much like pressure cookers. Restrictions were placed on boiler designs at virtually every conceivable level of government, so that today one could build a steam car safely if one wanted to get in and wait 30 seconds for it to drive off. You would have a perfectly drivable car, but the chances are that boiler design specifications are so radically different from county to county and municipality to municipality, that one would find it difficult to drive from one place to the next. This is one of the reasons that steam engines that have been designed and tested in Detroit for the past 10 or 15 years have not been produced.

Steam cars could be produced and, with these minor market liabilities, could be operated today.

Similarly, diesel engines, which have been marketed in passenger cars on a limited basis by Mercedes, could be produced. They could become more familiar than the internal combustion engine with which we are familiar, and we may see a greater development in the next few years, in terms of marketing.

The principal characteristic of the American automobile to which we have become accustomed is that it does start as soon as you turn the key on. It does have a wide range of driving characteristics, among which is its fast acceleration that, as I mentioned earlier, results in costs that are twice as high as for smaller vehicles which do the job adequately.

In the early 1900's, there were some 4,000 cars built in the United States or 8,000 registered. In 1928, there were 3,815,417 cars produced and 21,308,000 registered. It is interesting that from 1928 through 1949, the number of vehicles produced in this country on an annual basis, and the number of vehicles registered, do not follow exponential growth curves, but remained approximately constant, at 1 to 3.5 million per year, with registrations of about 28 to 35 million.

In 1970, we had approximately 3 million miles of roads in the United States. We had 90 million registered passenger cars, with an annual production rate increasing by 10 million per year. We produced 6.5 million passenger cars. We traveled 900 billion vehiclular miles. The energy -- the direct energy gasoline consumption resulting from this was 8,900 trillion BTU's. This, alone, was 13 per cent of our total energy budget. The total indirect costs were about 14,500 trillion BTU's or about 21 per cent.

I will conclude with one or two more points. In 1970, the average miles per gallon of a vehicle produced in the United States was 13.5. However, if one averages the miles per gallon on the basis of total energy costs per car, by using the higher BTU figure which relates to net energy use, then the total average was somewhat under eight and a half miles per gallon.

The principal increase in size and weight of the American automobile, has come about within the last 10 years. In 1963-65, the standard four door sedan with a small V-8 automatic transmission, power steering and power brakes, or the standard American car in 1965, weighed approximately 3,500 pounds and got 15 miles per gallon.

In 1968, the weight was up to 3,750, with an increase of about four and a half per cent. The mileage was down to 14.5, performance for acceleration was down eight per cent.

In 1971, the average American car weighed 4,150 pounds, and now included air conditioning, which was an option chosen in 60-80 per cent of the cars sold that year. The engine size was 350 cubic inches, with a horsepower range of 250-300. Mileage is down to 13.5 miles per gallon.

In 1973, the average weight of the automobile was 4,275 pounds, with a 400 cubic inch engine. Mileage was down to, approximately, 12 miles per gallon. At the same time, as I have already noted, there are a number of other technical considerations, such as compression ratios and torque ratios which affect fuel consumption, and then there are options such as power steering, power brakes, and air conditioning, all of which have been on the increase in production cars and all of which adversely affect fuel performance.

Of the various options that are available to consumers, there are a number of tips which have been bruited about recently, and most these are sound. They include keeping your engine well tuned, the tires properly inflated, driving more slowly, accelerating less rapidly, and so on. Chilton's, which is a major technical handbook on automobile maintenance, has recently published a volume on tuning and maintaining cars for better mileage, and I would highly recommend it.*

To conclude it is critical to note two considerations. One is that the concept of net energy efficiency is going to have to be incorporated into our energy consumption conservation in all levels of operation. Net energy debts are passed on to future generations. Right now, we are living in an accelerated age in that we have passed on the net energy debit to ourselves. For example, if a car has a life span of five years and has to be recycled in five years rather than in 10 years, the energy demand for recycling is going to be that much sooner.

Within five years, we are going to find that in addition to critical energy shortages, we are likely to encounter material shortages. We are going to have air, water and land limitations, and we are going to be faced with continued inflation for at least the foreseeable future. All of these are going to impact on our transportation alternatives.

There are small savings available on a consumer level to people right now in terms of maintaining vehicles at high standards, and that's about it. Cutting driving, and driving at slower speeds, are alternatives which are immediately available. They are not significant in terms of the long range energy picture. What is more significant is that Detroit could be marketing cars that are 50 per cent lighter than those on the road today, or 30 per cent lighter or 20 per cent lighter, and they could cut the engine size in half. That requires no energy technology. It will not impact on top speed. It will only impact on energy required. It will result in considerably larger energy savings.

In the 10 or 12 years ahead, we will have to examine alternatives to the automobile and internal combustion engine. New national goals are going to have to be reflected in the market place, in market decisions, and in committments on the part of state and local governments to develop improved mass transit. This will improve

*Ronald M. Weiers, Chilton's More Miles-Per-Gallon Guide, Chilton Book Company, 1974.

not only the quality of life, but ultimately allow us more freedom on the roads for the use of private automobiles as a personal, rather than a public transportation vehicle.

NASSAU COUNTY ENERGY CONSERVATION PROGRAM

Hon. Ralph G. Caso
Nassau County Executive

According to a recent survey, 88 per cent of the people in a Moroccan village had heard about American lunar landings, but 63 per cent of those who had heard didn't believe it.

Reports from the energy crisis in the United States sound pretty similar. Close to 100 per cent of all Americans have heard about it, but a substantial majority either do not believe that it was real or else believe that it was manufactured by the oil industry to boost its profits.

There certainly were enough reasons for Americans to be skeptical. For one thing, the crisis was sprung on us practically overnight, and then it apparently ended just as quickly, as soon as gasoline prices had jumped up about 60 per cent and oil company profits started hitting record highs.

For a while, there was a war of words over whether the situation was a problem or a shortage or a crisis -- sort of like the way that the Air Force recently changed over to using the term and I quote, "precision-guided munition" instead of "smart bomb" so that the public would not think that the rest of its bombs were dumb.

But when all was said and done -- and a lot more was said than was done -- local governments were faced with a host of headaches that they never had had before. Energy is supposed to be a federal responsibility, not a local responsibility, but, all of a sudden, the problem was dumped in our laps. Local governments had neither the authority nor the resources to solve the problem. All they could do was try to mitigate the effects on their local residents; try to see to it that people had enough fuel oil for their homes; try to insure that their areas were getting the fuels that they needed and that industries within their jurisdictions ish and counterproductive for any county or area to set up its own separate bus operation. It should all be brought under the umbrella of the Metropolitan Suburban Bus Authority so that we can develop a genuine regional plan.

There are other steps that state and local governments can take to save energy. The White House Office of Emergency Preparedness estimated two years ago that readily available and easily applied energy conservation measures could cut overall national energy consumption by as much as 16 per cent by 1985 and by as much as 25 per cent by 1990 -- if we adopted them. One of the principal areas was industrial operations where there has been a prodigal waste of energy, largely encouraged by favorable electric rate structures. When industry was being pinched by rising fuel costs, it showed that it could make significant reductions, in some cases reportedly as much as 30 to 40 per cent, without affecting production in the slightest. All that it took was plain common sense.

Another study has shown that if all the homes in the nation met the new FHA minimum insulation requirements, we would save about 26 per cent of all the energy that we would otherwise use over the next ten years. States and local governments should adopt insulation standards for all new structures, as California has done, and provide tax breaks and low cost loans for owners of older structures who are willing to bring them up to the standards. Along thse same lines, an experimental program in energy conservation in a commercial building, carried out by General Electric and reported in the Draft Environmental Plan for New York State, resulted in reducing power consumption by 35 per cent.

There is an old saying that where there's a will, there's a way. And we have more than the will to master our energy problem. We have an absolute necessity.

Fortunately, we also have more than enough ways. Nobody can tell me that the nation that put men on the moon cannot lick its energy problem, especially when the alternatives are so stark.

By 1970, transportation accounted for 25 per cent of all U. S. energy consumption -- with 55 per cent of that being burned in cars and 87 per cent of what was burned in cars going out the tailpipe as wasted heat and exhaust.

Now, I am not much of a mathematician, but I was able to figure this one out. If we use about 16 million barrels of oil a day, 4 million barrels are going into transportation. Of these 4 million barrels, 2,200,000 are going into cars, and 1,914,000 barrels a day, or 13 million barrels a week, or nearly 7 hundred million barrels a year, are being wasted. You can look at that another way, too. It means that you are getting only eight cents worth of driving out of every 60 cent gallon of gas.

That is an awful waste of energy and money.

One way that state governments can reduce the waste is to require Detroit to produce an energy-efficient car. Detroit will yell and scream that it cannot be done. But if New York State passed a law saying that, after January 1, 1977, for example, no new car could be sold in the State that did not get a minimum of 20 miles per gallon while meeting stringent environmental standards at the same time, Detroit would do it and would do it fast.

Even more important than making automobile engines efficient is our commitment to mass transit. People now take their cars instead of a train or bus because their cars will get them where they want to go quicker, more conveniently and more comfortably. If mass transit could be made just as quick and convenient and comfortable, people would gladly leave their cars at home.

But we need more than just mass transit in Nassau, or mass transit in Suffolk, on the other hand, or mass transit somewhere else. We need a regional mass transit network. The framework for building it exists already in the Metropolitan Transportation Authority and in the Metropolitan Suburban Bus Authority that was created last year to run the bus system in Nassau. At this point in time, it would be fool-plan in operation by 1980. Officials there expect that the plan will save state and local governments as much as 100 million dollars in capital expenditures by turning at least 60 per cent of the solid wastes into energy or reusable material. Air pollution will be cut 80 per cent and so will the amount of land needed for sanitary landfill operations.

Back in the Middle Ages, alchemists dreamed of turning base metals into gold. What an irony it would be if, instead of buying or burning our waste, we could turn it into black gold.

These are only two of the alternate additional energy sources that have been reported by reputable scientists and scientific organizations. There are others that may sound even more exotic. But there was a time when oil sounded exotic, too.

If astronomers were suddenly to warn us that they had spotted a new comet -- not a fizzle like Kohoutek but a real monster from deep space -- and that in thirty years it would crash into earth killing 30 million people and possibly jolt our planet out of its orbit, you can bet that we would mobilize every bit of scientific know-how in the world to figure out some way to duck it or deflect it. We wouldn't just sit around waiting for it to hit us.

Yet, that is exactly what we have been doing on energy, waiting for disaster to strike. We got a foretaste of it this year. And there is much worse to come unless we do something about it in time.

Developing new sources is one side of the energy coin. The other side is saving what we have, making it last longer, getting more out of it by using it more efficiently.

In a very real sense, the U. S. Government unwittingly laid the groundwork for the energy shortage back in 1956 when it embarked on the largest peacetime public works project in history -- the construction of interstate highways to foster economic growth.

scorn on solar energy proposals by focusing discussions on the most ambitious project. Converting the sun's rays directly into electricity may indeed be a long way off. But that is no reason to ignore the much more modest but demonstrably workable application of solar energy to heating and cooling homes, a process that now accounts for about 25 per cent of our total energy consumption. The technique is already well known. It is in use in several countries. There are pilot projects underway here. This month's Reader's Digest even has a story about a do-it-yourself solar heating and cooling system in Maryland that paid for itself in savings on oil within seven years. So it can be done. All we have to do is make up our minds to do it.

In my testimony before the Council, I got more raised eyebrows and knowing looks when I mentioned garbage power.

Again, I am not a scientist but I can read. In February of 1972, the Bureau of Mines -- a subsidiary of the U. S. Department of the Interior which in turn seems increasingly to act like a subsidiary of the oil industry -- released a report saying that solid wastes could be converted into "low sulphur oil potentially suitable for use as gasoline or diesel fuel."

If all the municipal solid wastes generated in the United States last year -- 130 million tons of it -- were put into garbage trucks, the trucks would stretch bumper-to-bumper, three abreast from New York City to Los Angeles. And within that waste there is locked enough untapped energy to light the United States for one year.

Several cities now have plants to convert waste into energy. They range in sophistication from old-fashioned incinerators whose waste heat is used to heat and cool nearby buildings to advanced technological projects that break down the molecules in organic matter and produce oil or synthetic gas as the end product.

The State of Connecticut hopes to have a statewide regional energy recovery places would be a whole lot worse off than they are now,

Yet, we still use more energy than we produce. We are still importing about 28 per cent of our oil and we are still just as vulnerable to political and economic blackmail now as we were in January. In fact, the energy crisis has forced us into a public examination of just how dependent we are on other nations for a whole list of essential items. We import more than half our mercury, zinc, bismuth, antimony, nickel and tin. We import 90 per cent or more of our aluminum ore, chromium, graphite, cobalt, platinum and manganese. We import 100 per cent of our coffee and natural rubber.

Obviously, we are dependent on other nations for far too many of our essential commodities, including oil. There is not much we can do about coffee and rubber. But there is something that we can do about our energy supply.

Last October, I testified in Mineola at the U.S. Council on Environmental Quality's hearing on offshore oil drilling. I was making the argument -- since sustained by the council's own report -- that the environmental price of offshore oil drilling was too high, especially when there were alternate sources of energy that could be developed if we made up our minds to end our reliance on fossil fuels. Among the alternatives that I mentioned was solar energy -- which prompted the Council chairman to ask me, very patronizingly, if I really believed that solar energy would work. I told him that, not being a scientist, I was not giving him my opinion, but that I was willing to take the word of the National Science Foundation and the National Aeronautics and Space Administration that it would.

In the past few weeks, the head of the Atomic Energy Commission has been sharply criticized by some members of Congress for allegedly suppressing a report from her own special study panel that said that a photovoltaic cell could be produced by 1986 at a cost competitive with more familiar forms of energy. Most advocates of other forms of energy -- nuclear power, for example -- manage to pour take to contain the problems.

Finally, we set up park and ride facilities in our County parks to encourage car pooling by commuters. And in February of this year, I proposed -- and the Board of Supervisors passed -- a local County Ordinance establishing an odd-even, maximum-minimum sale rationing system on gasoline. The state adopted a similar law a few days later and the length of the gasoline lines in the County dropped dramatically from an average 35 cars to only four or five.

What Nassau County did, what other local governments did, was to step into a vacuum. The only thing that might have been called a Federal energy policy was an exhortation to turn down thermostats and drive more slowly and, while these measures were certainly useful, they were hardly a policy. So State and local governments had to evolve their own stopgap, local energy policies. The only thing that saved us from disaster during the energy crisis of 1974 was the combination of good luck in the weather and good sense on the part of the American people who cooperated wholeheartedly in energy-conservation programs.

A lot of people are breathing easier now in the belief that the energy crisis is behind us. But if any of these people have figured out where their gasoline and fuel oil are going to come from in the months and years ahead, they know something that the energy experts don't know.

The real energy crisis is not behind us. It is ahead of us. And if we do not do something about it, it is going to hit our nation during our lifetime and cripple it.

Let me say at this point that I am not the least bit impressed by all the rhetoric about our burning 33 per cent of the world's energy even though we have only six per cent of the world's population. We also produce about 37 per cent of the world's goods and wealth, as measured by the Gross National Products. So without all that energy being burned here, a lot of people in a whole lot of were getting the fuels that they needed to prevent layoffs and massive unemployment.

Last summer, nobody was very worried about an energy crisis. But there were enough hints floating around, enough indications of a possibly serious problem when the weather turned colder. So, in August of 1973, I formed a County Ad Hoc Energy Crisis Committee. The Committee was composed of the heads of County Government agencies and representatives of the business community -- and the idea was to pool our knowledge and our resources and our know-how so that we could anticipate problems and plan ways to minimize them.

Out of that committee came, first, a number of in-house energy conservation measures that were adopted throughout County facilities. These included turning down thermostats in winter, experimenting with fuel oil atomization techniques, reducing lighting, curtailing the use of County vehicles and a computerized car pool system for County employees that gave favored parking status to people who traveled to work in car pools.

In September, Suffolk County Executive John Klein and I jointly proclaimed Nassau-Suffolk Energy Conservation Month. A major effort was made to disseminate energy conservation information to bi-county residents and businessmen. In Nassau alone, we distributed more than 500,00 copies of a leaflet entitled, "How to Save Energy and Money, Too".

When the real crunch developed in December and January, I formed an Oil and Gas Bureau and an Energy Conservation Bureau within our Department of General Services. Both zeroed in on getting proper fuel allocations for our county residents and business establishments, and on gathering data to make sure that we were getting our fair share.

We also set up an Energy Crisis Committee on the Economy, which enlisted top business leaders and economists into an effort to gauge the economic effects of the energy crisis on Nassau County and to recommend steps that County Government could

Those alternatives were scripted into a chilling scenario for the future by Professors Lawrence Rocks and Richard Runyon of C. W. Post College in their 1972 book, "The Energy Crisis." I would like to close by paraphrasing what they said:

The first signs of the impending disaster, they wrote, would come slowly: Increases in the cost of oil and gasoline, voltage reductions by power companies during peak hours, occasional dimouts. Then, the government would begin rationing essential fuels and urging the public to give up private cars. The curtailment in the use of cars would have an immediate impact on Detroit where the auto industry would be laying off thousands of workers. Soon, the steel industry would feel the effects -- and then a domino effect of factory shutdowns would sweep the nation.

Shortages of fuel and breakdowns in the transportation system would eventually cause food shortages as farmers would not be able to ship their produce to populated areas. The stock market would crash. Industrial growth would come to a standstill. The government, trying to stave off total economic collapse, would have to impose rigid price, wage and profit controls. Critics of these policies would be subject to severe penalties under new anti-sedition laws that virtually nullified the First Amendment to the Constitution. To survive, the United States would have become a totalitarian State.

Apocalyptic? Yes.

Exaggerated? Probably.

Impossible? Who knows.

Let's hope that it is. Let's do more than hope. Let's get started on doing those things that will make it impossible. Let's get started on developing a national energy policy that will let us get the most out of the energy sources that we now have and put us on the road to finding and perfecting new sources.

If that is our response to the energy crisis of 1974, it may well turn out to have been a good thing.

The Chinese character for crisis is composed of two other characters. One means danger. The other means opportunity.

The danger is clear enough. Let's not miss the opportunity.

TOWN OF HEMPSTEAD'S SOLID WASTE ENERGY PLANT

Hon. Alfonse M. D'Amato
Supervisor, Town of Hempstead

Mr. Chairman, County Executive Klein, County Executive Caso, distinguished staff, distinguished parties and guests, ladies and gentlemen, we in the Town of Hempstead, for some time have been plagued, as most municipalities, suburban and urban areas have been, with the problem of inadequate sanitary means of disposal of our solid waste. The Town of Hempstead produces approximately 3,000 tons of garbage per day. Recognizing that landfill area is quickly being eliminated, recognizing that there were very few areas in which we could establish new landfill sites, and recognizing that the problem of solid waste disposal has plagued 90 per cent of America's major municipalities, we established a study committee to look into possible alternatives to those methods which have been used by most of the cities and municipalities throughout the country. We found out some very interesting things. We found out, for example, that 90 per cent of those municipalities throughout the country disposed of their garbage not by incineration, but through burying their garbage. The vast amount of garbage in the United States is landfilled.

I submit to you this is not tolerable today in our society with the affluence, the techniques, the technical ability, the know-how and sophistication that has come to us through science, and also in what people have come to expect and literally demand. We, therefore, invited proposals from every major industrial complex throughout the United States, and advertised that we were interested in developing a technique that would reclaim the precious metals that you heard our County Executive Caso talk about, and reclaim other valuable materials that are being buried now as well as creating a problem.

In the Town of Hempstead, our major landfill site (190 acres in size,) is in the community of Oceanside. On some days, this site receives up to 2,000 tons of solid waste material. Literally hundreds and hundreds of trucks can be seen coming down the main thoroughfares of Austin Boulevard and Long Beach Road, traveling to this dump. We now have a mountain; a mountain which is 52 feet high, and growing. We estimate that we will be able to use this landfill site for four more years at the current rate of solid waste generation: up to 3000 tons per day.

It is a matter of necessity for us in the Town of Hempstead to investigate new approaches for handling solid waste. Last year, we were able to have legislation passed in Albany which would permit private industry, on a long-term basis, to come into our town and to put up their own monies for the capital construction necessary for the type of facility - a solid waste recycling facility - that we thought would be needed to handle our garbage. We are happy to say that the Town of Hempstead has written a bill providing for private industry's operating such an enterprise for 20 years. It passed both houses unanimously. I understand that this year the State Legislature saw fit to enact the same proposal on a statewide basis, which will now give municipalities throughout the State of New York the ability to similarly contract for the construction and operation of solid waste plants and facilities.

What do we envision in the Town of Hempstead? We have purchased a parcel of property located at Mitchel Field of approximately 15 acres. We advertised for a bid, and let the various people know that we were interested in a plant that would have the ability to handle 2,000 tons of garbage on a daily basis, and would have the ability to reclaim those metals and materials that are now being buried.

Our Engineering Department estimates that out of 200,000 tons of household garbage, we can reclaim 160 tons of steel a day, 80 tons of glass, 20 tons of aluminum and two tons of copper. Approximately 2 million dollars annually can be saved by the resale of these precious resources. In addition, the non-burnable reclaimable materials are the same materials which create the breakdowns, the problems, and the explosions which result from traditional refuse handling techniques. So we extract the non-burnables, and now make it possible, by a procedure where the remaining garbage is uniformly shredded and then burned, to produce approximately 225 million kilowatts of electric power.

We project that we can meet approximately 12.5 per cent of the power needs of the Town of Hempstead. We are talking about a town with 840,000 people. We are talking about meeting not only the residential needs, but all the needs, the demands by industry, commerce, and retail establishments, as well as our homes.

I am pleased to announce that on May 21, 1974 our Board will be adopting a resolution accepting one of the proposals which have been submitted to the Town of Hempstead, thereby giving us the ability to enter into a contract. We anticipate that the construction of this facility will start sometime this August. We anticipate it will take approximately two and a half to three years for the plant to become operational.

Because of the high cost of oil, we anticipate that this plant will yield us approximately 6 million dollars from the sale of electric power. Thus, the plant will have several results. We will be reducing the amount of landfill, because from the 2,000 tons of garbage coming into the plant on a daily basis, we expect to landfill only 30 to 60 tons of inert, sterile material. We will be producing approximately 6 million dollars in revenue for the Town by the sale of the electric power. We will also be participating in the sale of precious metals, and that will result in a revenue of 2 million dollars. Thus, 8 million dollars a year will be generated. This will be shared with the Town and with the private contractor who will not only build, but also operate, this facility.

We will virtually be eliminating landfill as a concept. We will be turning a liability into an asset. We do have the technical ability today to embark upon this type of endeavor, to turn our solid waste problem into a partial solution of the energy crisis.

It is estimated that if most of the Nation's municipalities that have this problem were to embark on similar projects, anywhere from five to 10 per cent of electrical generating requirements could be met. This is a great step forward.

I would hope that we, in the Town of Hempstead, have played our part in showing the way for other municipalities, not only in our region, but throughout the State and throughout the country.

DISCUSSION

QUESTION: How much will it cost to process a ton of garbage?

MR. D'AMATO: We pay $11.35 to bury a ton of garbage at the present time. That figure varies from municipality to municipality by a dollar or so. We anticipate that we will be able to cut the cost of garbage disposal down to from anywhere from $7.50 a ton to $9.00 a ton. There will actually be a reduction in terms of the money that the taxpayer is now paying to bury 3,000 tons a day. In addition, there will be no risk of capital on our part, because the facility will be completely financed by private enterprise.

QUESTION: Do the economies of scale permit you to set up a waste project, like the Black-Clawson Project, that can operate for a small municipality, handling say, 1,000 tons or less of garbage per day? Does it still have to be 3,000 tons a day to be profitable?

MR. D'AMATO: We started with the premise of getting maximum efficiencies. Our own engineers came up with a figure of 1,600 to 1,800 tons a day, which would be the best as far as economy is concerned. We asked, in our design criteria for a plant capable of expanding from 2,000 tons to 3,000 tons a day within a period of five years. Twelve hundred tons is about the minimum capacity you should look into. If you get below this 1,200 ton per day figure, you are running into cost excesses, because of operating expenses.

The construction costs of building an incinerator are about $25,000 per ton. So, I would suggest that it is not economical to build your own incinerator, say, with a 500 ton per day capacity. I would suggest that smaller communities should investigate getting together in such a way that the appropriate amounts of garbage could be collected.

ENERGY FROM WINDS AND SEA THERMAL GRADIENTS

Prof. William Heronemus
University of Massachusetts

INTRODUCTION

Ladies and gentlemen, I will attempt to talk about two solar energy processes that share one thing in common. They both share a concept of natural collection of solar energy.

This morning we heard a great deal about the heating and cooling of buildings using solar energy, and that particular process is sometimes given the name of the low temperature photo-thermal process, which might frighten you. In other words, the greenhouse effect.

There are at least 11 processes which are identified as of today which, indeed, could do a lot of good for us, -- and you can't imagine how pleased I was to hear a Town Supervisor talk in such solid and far-reaching, far-visionary terms in favor of solar energy compared with what happened to us in the Town of Amherst only a week and a half ago at a Town meeting. It was, indeed, a pleasure to hear some solid words of backing.

If you think in terms of all of the solar energy processes, each in a sense augmenting the other and each, in a sense, taking advantage of the natural terrain and meteorological situation, in which it can best work, then you have an energy source of the future that is, indeed, astronomical in size. This is, probably, the first thing that we should really admit, that all in all the overall size of the solar energy resource is at least three orders, probably four orders of magnitude greater than that which the entire world demands for energy today.

We can move and we should move from what we are doing now towards solar energy, and we can do it confidently. We can do it without any fear of having to walk the cat back a long, long way.

Now, one day of course even this resource reaches its finite limit, and the very fact that it is finite is wonderful in my mind because it says that one day all of mankind on earth will have to live within a thing which you call the world solar energy budget, and it is something people aren't going to be able to fudge about. You are going to have to get together and talk about it, talk about how large it is going to have to be and how we are going to share it.

There is one characteristic about solar energy that goes along with the fact that it is such a resource; that it is a very diffuse resource. It is spread very, very thinly. It is lean energy, particularly to the civilized and highly industrialized man of this decade. It is a very, very lean resource. So, one of the problems we have in using solar energy is figuring out how to gather it together over an area that makes it meaningful to the way we want to use energy, and, then, get on with it.

WIND GENERATORS

Winds are created and driven by solar energy and they constitute, in a sense, the process for natural collection, for natural amplification of this lean source of energy. There are regions in which the winds can give us instantaneous power that may be 30 to 50 times as great as the power that we are receiving on flat ground from the photo-thermal effects from the sun, itself. I would like to use some slides from here on to talk about the wind and wind power.

The first slide is just a review here, quickly, of what the winds are all about, and this is a view taken up above the North Pole looking down on the Northern Hemisphere. The point I wanted to emphasize is there, off to the left, you have the Atlantic Coast of the United States, and flowing off of the Atlantic Coast of the United States are the westerlies. The larger the arrow, the stronger the wind, and the stronger the wind velocity, the stronger the energy. The energy varies with the strength of the velocity, a very significant factor.

Those westerlies are literally drawn from our continent. They aren't blown across our continent. They are drawn out there into that region south of Iceland and to the west of Ireland which is, almost every day of the year, a low pressure area, one of the largest suction pumps on the face of the earth; and this particular feature allows us, literally, here back on the beach, if you will, to use wind energy that isn't really identified with our rather narrow strip of land or our rather narrow continent. We can take advantage of an atmospheric and oceanic process which extends and covers out there, maybe, two to three to four times as much area as our own land mass.

Now, winds have excited the interest of men for thousands of years. Wind has done great things for people in the past. In fact, New England rose to the peak of financial success no more than 70 or 80 years ago because of their use of solar energy and, particularly, because of their use of wind power and their use of that other solar energy process, -- the one in which the sun evaporates the water and lifts it up, and when you let it flow down the hill, you can use the potential energy it creates as it flows down.

Many other nations have had wind programs; among those was a program in Russia. This particular machine was installed in 1931. It was relatively tiny at the time, only a 100 kilowatt machine, but showed some very, very advanced aeronautical engineering. In fact, people were surprised that the Russians knew so much about aeronautical engineering at the time.

The time this was going on in Russia, there was even a greater trend toward this way in England and France. There was a particularly great trend toward it in Great Britain. They realized how fast they were running out of coal. But what really solved their energy crisis for them at that time was the ability, particularly by the United States of America, to distribute petroleum products at a very, very low cost in Europe and elsewhere, and also the production of the diesel engine at a very low cost per kilowatt. The combination of those two things killed all of these developing wind power research programs.

Here in the United States of America, we had a very good wind power research program headed up by an M.I.T. team in the late '30's. It started, really, as a venture with the Morgan Smith Company of Pennsylvania. They combined with General Electric and M.I.T., and their product was the world's largest wind generator, the so-called Smith-Putnam generator built near Rutland, Vermont.

This machine did work. It was 175 feet in diameter. It generated 125 megawatts, and it did this in synchronism with a Vermont line, but the whole project was a failure. With only two blades, which were actually built from stainless steel, it was just too revolutionary. Through the vibrations of the wind machine, one of those broke off before they had done too much good with it.

It was also an economic failure. It was just scarcely an economic failure, but enough to throw cold water on wind programs around the world.

In 1970, I decided to take a look at why that might have been considered an economic failure and what could be done with it now to keep it from being an economic failure. One of the problems was that they offered to sell electricity only when the wind would blow. It was a fuel saver, and they had to compete with what we call the differential cost of fuel. It was coal in that day, and the cost of coal was regulated within a couple of pennies per ton for almost 28 years in a row, and they just couldn't beat the competition.

So, how can you get around this? Well, we posed a question to ourselves, "Is it at all possible to build self-contained wind generating systems that could sell electricity on demand and, therefore, command the entire rate structure so that we could also get the revenue from the peak, the intermediate, and the base load rather than this, which did nothing else than dump power?"

We took a look at other possibilities, e.g., a wind power system with storage. Here is a block diagram of one concept.(Figure 1.) Those wind generators that you see in the upper left-hand side are going to be relatively small; probably, the largest wind generator we will see will be no larger than four megawatts and we will probably see fairly large numbers of much smaller generators, and each one of those will extract energy from the wind as the wind happens to hit it at that site.

You have to provide some kind of a parallel or summing up network, and I have shown you two machines there drawing electricity into a paralleling system, and that one at the bottom represents an old type Ward Leonard system. There will certainly be some solid-state power device to sum up from those individual generators and then deliver it to the customers in the form which they want it. The customers want 60 cycle AC electricity in the United States. They want it at 110, 220 or 440 volts at the customer level.

So, here we have a system then that starts off, and it says that we will collect energy out of the wind with this very large number of wind generators, and we will sell it to the customers. Now, how do we work out this system so that we can sell electricity on demand?

Well, if you look at the energy content of the wind, which is a function of the cube of the velocity at any one site at a given height over a short period of time, it is totally capricious. You come up with statistics which are useless. If you take a look at that system for a period of a month, you will see a surprising reproducibility. If you look at it in the course of years, you will find reproducible results.

In fact, an analysis on this is very similar to the analyses we now use to make wind-wave analyses. We have a darn good handle on this now because we look at the energy spectrum to take that point of view.

Examination of the yearly energy spectrum enables you to determine: a. the total

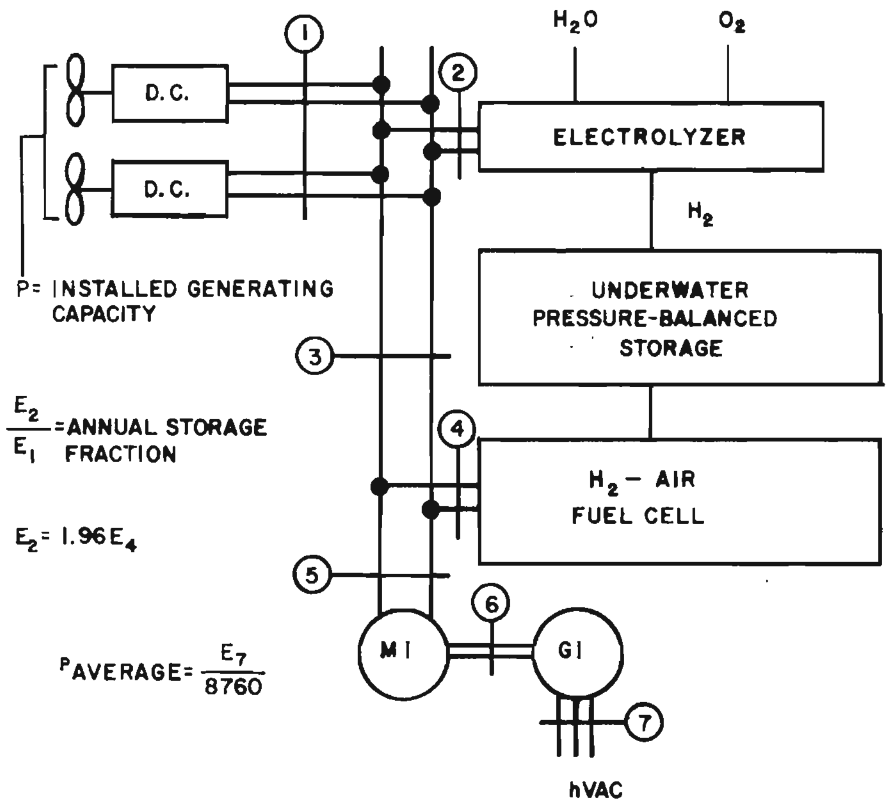

Figure 1. Wind Power Generator - Hydrogen Fuel Cell System.

amount of kilowatt hours per year; and, b. the number of hours during the year when there is no generation capacity. When this information is compared to the low demand curve which is given at the site, you will have a pretty good idea of how much of the energy you will have to store away when the wind is blowing freshly so that you can recall it and put it out to the customer when the wind isn't blowing well enough.

So, all around to the right side we have the storing sub-system which is based on the electrolysis of water into hydrogen, and the hydrogen becomes storable.

There are other storables. Possibly, the other form of storage is methanol. We are looking at that right now.

Another storage system is one in which you, again, make hydrogen -- but in this case, you liquefy the hydrogen. This is very expensive as of right now. It costs about five kilowatt hours of hydrogen to liquefy it, and the thermal dynamics is just about under three kilowatt hours per pound of hydrogen. If we could achieve plans to liquefy it close to this, this could make a lot of sense. Hydrogren is much easier to store as a liquid than as a gas.

The only economic way to store gas is to put it under deep water in gliders, -- gliders that are built inside of pressure balanced structural protectors, inside concrete spheres or concrete sections so that the leakage potential is approximately zero.

Therefore, putting these two ideas and a couple of other ideas together, we had to work out a scheme for quantification of any one wind regimen, and here we used a standard machine. Here we have a 30 foot diameter project that was done a number of years ago.

We have real results for that machine, and we said, "Let's just put that machine on a 20 kilowatt generator on top of a long pole and then set it at any wind regime from the Rockies to the Coast of Nova Scotia, and the kinds of results you come out with are the number of kilowatt hours of productivity that you are going to get per year."

Now, if you divide that number by the installed size of the generator times 8,760 hours per year, you come up with a number called plant factor; this is a good indicator of how you are comparing with other things.

I have no plant indications under this that are greater than .30 on average.

Then, we made a study to see how much of that stuff we would have to siphon off and store away in order to sell energy on demand. In making that study, we came up with interesting numbers. One used Canadian data. We found out that wind increases over the Great Lakes once you go 15 to 20 miles into the Great Lakes. The winds intensify considerably. So, out in all of these lakes and particularly the ones that are oriented from west to east, you have an excellent wind field. The same thing happens offshore.

We know this to be a fact because we took wind readings every day there for seven years in a row.

If you move from Providence, Rhode Island, or Georgia, to the Texas Tower, kilowatt hours of productivity rise to almost 100 kilowatt hours, or 43,613 kilowatt hours a year.

In New York State, over Lake Ontario, you have 74,000 kilowatt hours per year. You are sort of blessed there. You have good wind on top and good wind underneath and, possibly, you have some pretty good wind in between except, possibly, right in the vicinity of Albany.

Back in 1938, the Norwegian scientist, Sven Pederson, made this diagram for the Palmer C. Putnam team. He took that one and a quarter megawatt machine at a height of 150 feet above level, and he put it all over the surface of the earth. He said, "What would be the annual productivity of each kilowatt of that generator anywhere on the surface of the earth?" And he came up with these rather startling numbers. The place where the real wind power is, of course, is offshore. It is out over the ocean and it is especially strong down near the Coast of Africa and down near the Indian Ocean in what we call the roaring '40's.

Up in South Greenland, just below the ice belt, you have very strong winds, but they also come in close to our Atlantic Coast. In fact, the data taken at the Texas Tower for our New York shoals, show that the wind was a little better there, and for the Nantucket shoals the data were almost as good.

So, you have this tremendous sweep along the Jersey Coast, south of Long Island, and all the way out there, in which the winds are very, very strong.

Now, how strong are they and what do they do about replenishing themselves?

Well, on an average, the rate at which solar energy renews the collected energy and the winds in this particular regime, is at a power level of about 15 watts per square meter. You figure that out on a per square mile basis and come out with about 38 megawatts per square mile. You have about 920 square miles of land area in Suffolk County, Long Island, which means you have about 24,000 megawatts of wind power roaring over you day in and day out. This gives some idea of the rate at which that resource is replenished.

Now, if you can come up with a system that takes out or extracts a relatively tiny portion of the rate by which it is being replenished, maybe you have something that will go on, and on and on. As a matter of fact, that's what we came out with when we studied wind power programs for Long Island.

In this system, I abandoned the electric cable completely, except to tie individual stations to electrolizers. We used all the electricity to generate hydrogen and put the hydrogen in pipelines to use it as fuel to then generate electricity all through New England via pipelines not as electricity using cables.

When we have pure hydrogen from the electrolysis, and take the oxygen out of the air, the most desirable energy system is the fuel cell because of its simplicity and efficiency.

The fuel cell will also give you, as a by-product, pure water and that pure water, as time goes on is going to be a very valuable product. In fact, this kind of a system now is not only an offshore wind power system which can deliver electricity to us, but it also delivers hydrogen and wherever we reconvert that hydrogen in a fuel cell, it is an offshore desalinization system, as well.

We can show in a block diagram a large number of wind stations with variables reproduced for wind energy. At the electrolizer stations some of the electricity must be used to distill the ocean into clear water. Then you break that water down into hydrogen and oxygen.

From the block diagram, we see that we have to go to sea. You have to get out there where the winds are. You have to stay out there, you have to float out there, and remain afloat in hurricanes.

This is just one concept -- the only one I have had an artist take a shot at. We have many more projects, possibly more technical than this. One is a seagoing wind power station that is a wind velocity station. There are wind driving machines, each driving a 2 million kilowatt generator, and those designs were tested for us at the University of Stamford. It was done in 1945 and '46, and then they put their results on the shelf. I dragged these out in 1970 and copied the data. They could be improved on. As a matter of fact, as the last three years have gone by, I am convinced I can get at least a 25 per cent improvement in technology that we can now put our own hands on. We are confident of that.

We want something that will stand upright. We want something that will bob up and down with a very low frequency, with a natural period of at least 22 seconds. Our controlling wind out there in the Gulf of Maine is within the 22 second period. I have to get something between 22 or 23 seconds, no matter how strong the wind or no matter how violently the hurricane blows.

What do we do when the hurricane blows? Just lean back, let the wind keep on going -- this is a tremendous advantage compared to constructing a building on land where a civil engineer has to face those winds by standing upright and taking all the movements, particularly the gusts and so on. (Figure 2.)

Now, how can you put it all together for Long Island and for the rest of the country? For this six state region, the New England region, we put together a system that we say could produce continuously 360 billion kilowatt hours of electricity per year. Now, that is almost nine times as much electricity as we consumed last year in the six state region. Here we have a chance for growth. Here we have a chance for converting all of our heating, if we want, to electric heating. Here we have a chance for converting a lot of our terrestrial transportation to the consumption of hydrogen, or we can use that hydrogen, or we can use that hydrogen plus some coal to get us methanol and get back to a clean fuel or a fuel that can be made in a process where you can control the contaminants.

Here you have a system that, as far as I am concerned, works out -- and we have really done a great deal of work on this.

The cost boils down to less than what we are paying for electricity right now. People say, "Why don't we jump and start doing it?" The response has not been all that great in terms of, "This is wonderful. Let's get with it."

Perhaps the idea is too old fashioned for them. Perhaps, it is too new for them or, perhaps, they don't really care, or perhaps they don't really have the kind of imagination that's required for this sort of thing, or perhaps they have got their minds made up.

I frankly think it is the last that is giving me the most trouble in New England, because our utilities do have their minds made up. They went through some very excellent engineering studies in 1965 and 1968. They should be given a great deal of credit. They came out with the wrong answer, that was the only thing.

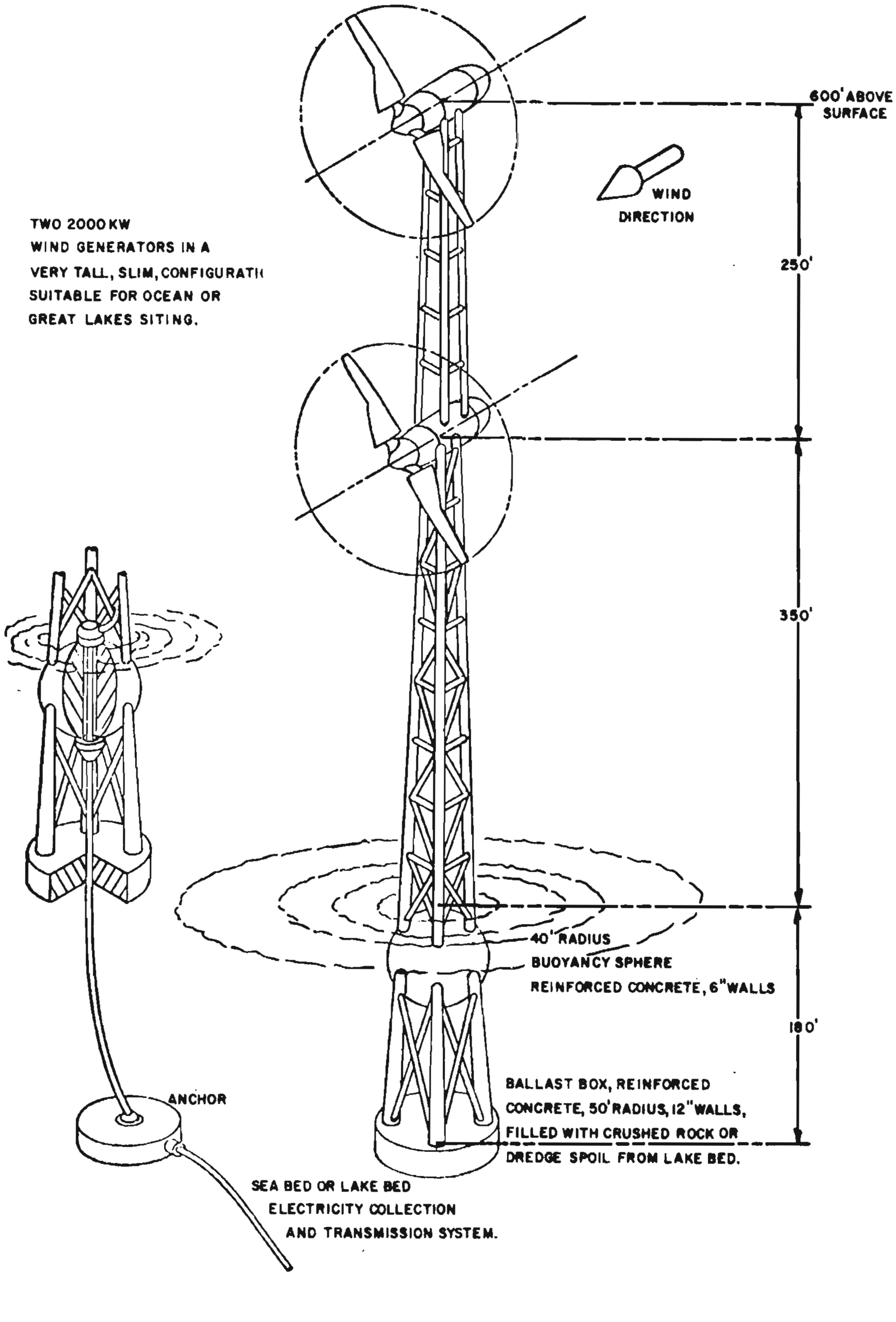

Figure 2. Twin 200 Foot Diameter - 4 MW Floating Wind Station.

In 1968, the answer did look right. In 1968, the answer was very clear cut; we should go to base load nuclear power plants and pumped hydraulic storage. The economics were quite clear cut. They were, however, based on some false assumptions; one, that nuclear power plants were going to cost 150 dollars per kilowatt hours installed and it was going to go down.

Of course, those of us who have watched what has happened, can't seem to recognize the difference between 540 dollars per kilowatt and 750 dollars per kilowatt.

The other bad assumption was that we were going to find those 35 sites for pump hydraulic storage that are essential. We have only built two, and I doubt whether they will ever build the third one. In 1968, a few other things had come to light involving the disadvantages, particularly the economic disadvantages of the nuclear power philosophy. I am not going to expound on that at this time.

I started off on my research on the pollution free energy program in 1970, and the first thing that I thought should be done was to get on with building large numbers of light water reactor nuclear power plants and locate them in the cold waters of the ocean. I did have a considerable amount of experience in the U.S. Naval reactor program, and I was going to cash in on the fact that there was really a great deal of economic advantage to that system, and that extra money could be spent in putting things to sea where they could do no harm. In the last three years, I have become convinced that this scheme was a very bad alternative on my part.

One of the things that you were told this morning was that we must all start to pay attention to the net energy concept. If we don't understand it, we ought to get somebody to tell us exactly what it means, because this is the sort of thing that, if we don't get with it pretty soon and recognize that we have to get to these renewable energy resources, we are going to be in great trouble.

OCEAN THERMAL GRADIENT POWER PLANT

I want to go on to another energy process which is applicable to all of New England and Long Island and, in fact, the entire United States. The plants may not be located here, but they can be located near enough so that the products can be delivered here. This process is, also, based on natural collection of sunlight.

This is a catamaran submarine lying underneath a sailboat. The sailboat is on the surface of the sea and down underneath hanging on four towers, you have a semi-submergible hull not at all different from the semi-submergible hull that they are going to use for drilling for oil on Georges Bank (because we can't stop them from doing it over there).

I want you, first, to picture in your mind's eye the globe, fasten your eyes on the equator and then let your eyes move between the two tropics and look at what you see there in that zone on the surface of the earth. That is the zone in which about 50 per cent of the incoming radiation from the sun lands, and that particular zone is 90 per cent ocean and only 10 per cent land.

So, a tremendous portion of all of this incoming solar energy, this diffused energy, hits the surface waters of the tropical seas and creates tremendous heat. It is a natural collection site, and that heat reservoir is just about 600 feet deep.

There is a temperature difference as you go from the surface down, but in about the upper 600 feet, you will find that nature has stored away this amount of warmth, if you will, and in that particular portion of the world, the difference between summer and winter is hardly noticeable. As a matter of fact, those waters seldom rise about 15 degrees Fahrenheit or go below 75 degrees.

This reservoir is so large that it doesn't reflect the difference between day and night. Here is a system where the difference between daylight hours and darkness hours, doesn't exist as far as energy is concerned.

Now, if you dive down anywhere in this tropical water until you get to about

1,200 feet beneath the surface, you will find you are in water that's almost freezing. Between the surface layers and that bottom cold water, we have a temperature difference that, maybe, is as small as 17 degrees centigrade and as large as 25 degrees centigrade, and we can build heat engines that will work across that tiny temperature difference. It has been done. This process has been demonstrated. In fact, any time you see an air conditioning plant or a refrigerator plant, you are looking at something that demonstrates the exact opposite of the process that I am talking about, the inverse of the process.

What is required to make this heat engine work is that you use a working fluid that is a refrigerant working between 15 to 20 degrees Fahrenheit. We have developed this kind of a system. When I say "we," we are Johnny-come-latelies. We were told in 1881 by Powell about it, and then his student, Georges Claude, did it in 1928. They were going to practice this in their French Equatorial colonies and then they gave up when their colonies then split.

We have been looking at this plant now for about 20 months. (Figure 3.) We have conceptualized this kind of power plant. This is only one kind of power plant.

We have restricted ourselves to one site. We picked out a site within cable distance to the other 48 states. You have a path along the western edge of the Gulf Stream, 15 miles from west to east and 550 miles from west to north. This path comes within 12 miles of Miami Beach. By the time it gets up to Jacksonville, it is 104 miles off, and up off Charleston, it is 160 miles offshore.

Within that path, which represents quite a few thousand square miles of ocean surface, what have you got? You have a water depth of no greater than 2,400 feet. Most of it has a water depth of only 1,200 feet. You have a temperature difference of at least 17.5 degrees Centigrade all year round, and you have the Gulf Stream replenishing that hot water reservoir at a rate of 30 million cubic meters per second.

Thirty million cubic meters per second is the equivalent of 3,000 Mississippi

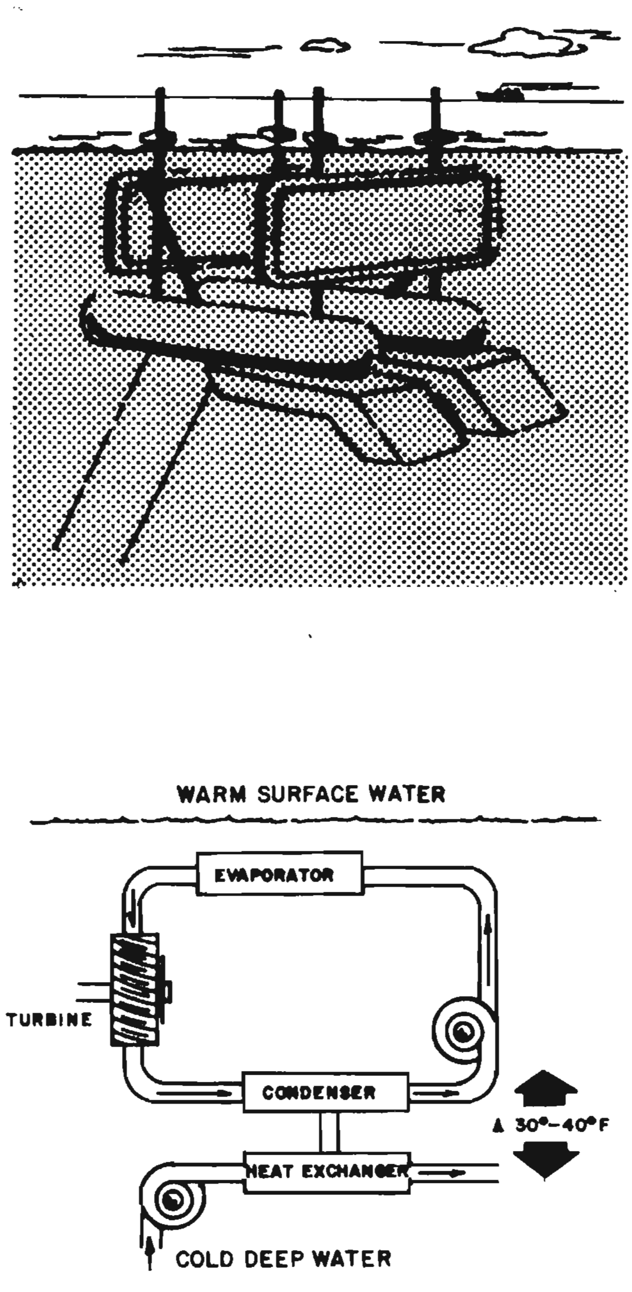

Figure 3. Ocean Δ_t Power Plant.

Rivers flowing in its maximum flow. That's a natural source which is driven by geophysical processes.

Now, the cold water is not as cold as we would like it and the hot water is not as hot as we would like it, but we are within cable-connecting distance from the beach, and this is where we say we would go for the first trial of this system. We said we would use this kind of power plant. The Gulf Stream flows from the left-hand side across those lines which represent evaporators, and then flows out the other side of the diagram. (Figure 4.) The evaporators are rigged up there into the hot water.

Into the bottom of those waters, you put your liquid refrigerant and it rises up in a two phase heat transfer, takes heat out of the ocean through the walls of the heat exchangers. It becomes a vapor which is not very hot. It will be something on the order of 80 degrees, or it will be less than the temperature of the hot water at that point, and pressure is relatively low. We are talking about working at a pressure of 115 pounds per square inch.

We now have vapor being created in the evaporators on top of the plant. The vapor flows down inside those holes and goes through turbines and expands through those turbines, and the turbines produce electricity and the vapor flows down and goes into condensers. We keep them cold by bringing cold water up from underneath.

The turbine hull is up in the top, the upper level, but the bottom is primarily a cold water distribution canal. We bring up cold water, and we have to achieve a very good turbine efficiency. We let the turbine control the power package. We come up with a power package that is a 50 megawatt gross on the shaft and about a 37 megawatt gross with a 25 megawatt net that comes out of the generator. Parasitic losses are very, very high. All of the pumping that we have to do, both of the cold and hot water, costs us a lot, but we still have a net output here per power package of 25 megawatts.

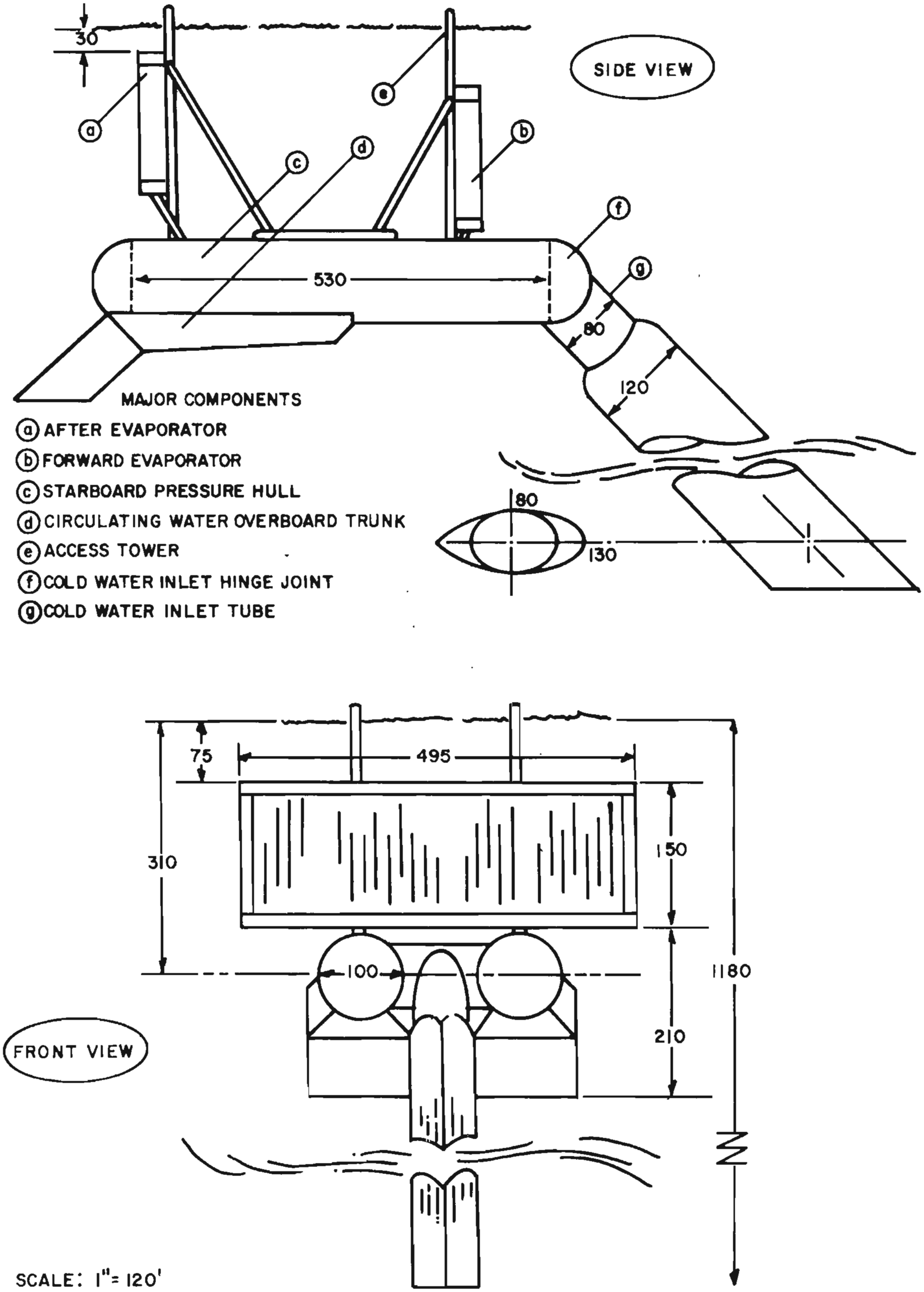

Figure 4. Ocean Δ_t Power Plant Components.

The largest power plant that we thought we could put together was one which comprises 16 of these power packages, a 400 megawatt electrical power plant. That's a pretty darned good size power plant.

We could establish any multiple of 25, and it may be that we will want to come back down from that 400 megawatts to something smaller.

The more of these things you can put in any one site, the less the per unit cost of the anchoring system, and that's going to be a fairly expensive part of the system. We have costed these things out innumerable times. We started our research on the basis that if we can show technical feasibility of one complete set of components, and if we can show that these things cost on the order of 400 dollars per kilowatt installed, including the necessary energy, we would have won a major victory. That was three years ago.

One year ago, United Engineers and Constructors of Philadelphia said at a meeting that this power plant or any other that could go on line in 1980 requiring no fuel, could cost less than 1,100 dollars per kilowatt, and still win any competition with nuclear or fossil fuel.

We have upgraded that number and as of this month, we can come in under 1,400 dollars per kilowatt installed. We are going to win the blue flag, and I think as each month goes on, we are going to have an even better chance.

The heat exchangers are going to cost the most money. The low efficiency doesn't matter insofar as fuel economy is concerned, because the fuel doesn't cost you anything, but what does hurt is the size of the evaporators and the size of the condensers.

We are looking at four different metals and one very interesting plastic, and we are looking at the D.C. cable umbilical back to the beach, and we are, also, looking at the completely self-contained hydrogen umbilical in which we take all of that electricity, electrolyze water and send the hydrogen back to the beach. We put it in pipelines and then, once again, go through the reconversion.

Adding all of this up, we arrived at a low number and a high number. We have one concept in which December, 1973 costs looked like only 289 dollars a kilowatt, including 15 miles of umbilical. We had another one, the one we liked the most, with copper-nickel metal, which looked like about 750 dollars per kilowatt.

We will probably bring the top one down and bring the lower one up, at the end.

How does all of this end up, particularly insofar as Long Island is concerned? If that power plant costs 600 dollars per kilowatt installed, 15 miles off Miami, you can deliver electricity to the beach at a total generating cost on the order of 12 to 14 mils per kilowatt hour. It is mighty cheap electricity. In fact, that is so cheap that you could afford to transmit that by direct voltage, DC transmission lines, all the way into New England. In fact, the number I have been using is taking it all the way to Burlington, Vermont. Then add the cost of that transmission, owning that transmission system, and then add 10 million for distribution, G & A and profit, and you can still come out with electricity that, right now, would cost less than what you are paying on an average in Burlington, Vermont.

You people on Long Island are mighty close to the same number. In fact, if some of the events of the last couple of weeks continue here, like what has been happening with Con Ed and Combustion Engineering, and a few others, why, I would hesitate to guess what your electricity is going to cost by 1980. I would suggest that you would be well advised to be asking yourselves these questions seriously, "What is it going to cost? How much of this are we going to get stuck with as taxpayers," and so forth and so on.

As far as the economics of this situation is concerned, we think we could reach the Chicago and St. Louis market and sell electricity competitively.

What about the size of this resource? This particular resource in the Gulf Stream, alone, as I showed you, could take care of the entire projected demand for energy in the United States way out into the middle of the 21st century, following an exponential curve.

If you will just remember that, probably, the system I have described is not as good as the one that goes to sea; the one that goes down where the temperature is at least 25 degrees Centigrade on the high seas at the equator, and has power plants tagged by liquefied hydrogen tankers that will bring the fuel product back to the beach. Then you will see not only what we can do, but what the entire rest of the world can do, what Japan can do and industrialized Europe can do, and others as well. Then, we will be able to take advantage of one-tenth of the incoming solar energy, which is available to this process. You can see what this might mean to the future.

ENERGY POLICY

Just let me conclude here with a couple of comments about energy policy. We do have an energy policy in this country. It might not be too clear, but there is the energy policy of 1971, fresh out of the White House. Since 1971 it has taken a few modifications, some of them deliberate, some of them a little bit not so deliberate, and we have, also, some plans for making some changes to this, but this was the policy in 1971: the policy said that the energy demand in the United States of America was going to grow, and we weren't going to do anything to stop it. As a matter of fact, we were going to do everything we could to make it grow. We were going to do it based on combustion, and we were going to do it with gas, oil, coal and nuclear energy. When we ran out of gas, we were going to get all the additional gas we wanted by bringing in liquefied bottled gas. We were running out of oil, but we were going to let our demand for oil grow and whenever we dangled the American dollar in front of whoever had oil, he would sell it to us at $1.65 per barrel. We were going to continue to choke down on coal for a while yet, for about 20 more years, and then we were going to have to expand its use. Then, nuclear was going to grow until 1985. Then, the only way that we could continue to grow would be the liquid metal fast breeder reactor.

There were a number of things that were very, very wrong with that policy. In fact, today's policy is entirely too similar to that 1971 policy. About the most significant suggested change that has come out recently is from the Ford Foundation energy study. They said if you go over to the year 1985, if you look at the top curve, it says one hundred seventy-seven quadrillion BTU's of energy per year.

The Ford energy study has written out three scenarios so far. We have three ways of going, but they all hinge around the year 1985, and all three of them say that we have got to change something by 1985 or something is going to change us, and it is going to change us drastically. In fact, the biggest thing wrong with that plot is that it spells total change in lifestyle. As far as I am concerned, that spells a depression and diseconomies that we have never seen the likes of before. Exactly how we get around to laying the consumption curve over is the thing we should all be working on. One way of trying to lay that curve over and, particularly, of getting the oil and gas curves pushed down to where we are not dependent upon foreign resources, and, perhaps, keeping that coal curve to where we won't have to tear all of Wyoming and Montana apart, is to face up to this net energy concept that is now finally coming out of the woodwork and being talked about. As far as nuclear power is concerned, the only possible way to come anywhere close, in my opinion, is to get on with solar energy that could be ours. It could be ours in the very near term. It could be economical.

It is almost impossible to pollute with solar energy. It is certainly impossible to heat up our ground water. It is essentially impossible to create air pollution with that type of energy.

The only type of pollution is a possible visual pollution and here I think, perhaps, we have to take a look at what we really mean by that.

This morning, a question was raised here, "What are the incentives for us to get on with these things?" And the answers were not too clear. I would just like to leave with you the idea that the incentive might be nothing less than survival. In fact, I would like to suggest to you that the incentive is, possibly, one darned sight bigger than our pocketbook. Though I, myself, am convinced that we would have fatter pocketbooks if we got on with solar energy.

We have reached the point in time where some very revolutionary things are happening to us. I would suggest that the first one that happened to us was way back in 1968, and hardly any of us paid attention to it.

In about November of 1968, following a 55 year period of constant reduction of real cost of electricity delivered to customers, suddenly the curve hit the bottom and began to rise sharply. Hardly anyone paid attention to it. It was probably one of the most significant things of the decade of the '60's, just loaded with tremendous impact and, perhaps, if that kind of thing is beginning to catch us here off base, like we got caught three or four weeks ago, where a few of us radicals sat around and talked about maybe we ought to nationalize the energy industry, and all of a sudden one of the blue chip utilities stands up and says, "Nationalize it. We can't carry it any longer."

Then, we talk about nuclear industries being able to pull it off, and I would suggest and say again that if you took all subsidies off of our nuclear industry, they can't begin to have that curve; and just a few weeks ago, one of the big three had their stock drop 60 points overnight because somebody let the cat out of the bag as to how really on the verge of economic collapse they have been now for about 18 months, trying to make that last big one work and it isn't working yet.

You take a look at the pending litigation that Westinghouse is involved in --- four claims against them for turbines that aren't doing what they are supposed to do. If they lost all of those cases, it could wipe out every bit of their reserve.

We are facing some rather drastic things. Those folks who suggest that the best way to keep the American lifestyle, the good old American way, is to try to follow that same nonsense, better be careful before they drive us into one of the damnest changes in lifestyle of any period on earth.

Thank you very much.

DISCUSSION

QUESTION: You said that the reason you were involved with a plan for offshore nuclear power plants a few years ago was that you thought they could be economically feasible as well as safe. My question is, in view of the Shoreham reactor and the two in Jamesport, which will provide power for Nassau County, if they are not safe enough to be built in Nassau County and they are only safe offshore, why are they being built at all? Rather than talking about the economics or the diseconomics, could you expound a little on what you believe to be the dangers of nuclear power?

HERONEMUS: I was very proud of our nuclear submarines, and we turned out a very high quality product. I came to realize that the reason we turned out a high quality product is that none of the people asked how much it cost. There was no stinting, absolutely no stinting and, primarily, because of the personality of the individual in charge, -- if I can just characterize him as one of the most unusual members of the human race on the surface of the earth today -- I came to realize that when I started looking at the offshore nuclear power plants, they are, by comparison, shoddy; just plain shoddy.

The big proposal of Lewis Strauss back in 1954 was that we could make nuclear power on the beach, compared to what Rickover was doing, by making these power plants much, much larger; therefore, the per unit cost would go way down.

Number two, we can make them economic by achieving an overall availability of about 93 per cent instead of the less than 40 per cent that the Navy has ever asked in their power plants; and the third one is, we can make them economical by using very slightly enriched uranium compared with the very highly enriched uranium that the Navy wanted.

They started out on that basis. The whole program, the whole shore site nuclear power program is really based on those assumptions, and I have come to the conclusion that they did not meet those assumptions. In fact, they fell far short of meeting those assumptions. They were in financial difficulty long ago, and the real truth was kept from us.

Now, I am not sure that I know why the real truth was kept from us, but it was kept from us indirectly -- I don't recall a single instance in the period from 1954 to 1972 when anyone in the Atomic Energy Commission ever bothered to come out and say that the cost of these things has been changed. We are still holding under 200 dollars a kilowatt, but we are doing it by slipping the money under the table or we are doing it by letting them take certain losses off the balance sheet in Westinghouse, cheating in combustion engineering and so forth. That's exactly what has happened.

The things that have happened -- first of all, I don't think we have come anywhere close to achieving the quality ashore that we did afloat, and I raised this question in my own mind. I said, "You know, if 110 people, admittedly the finest people in the world, all men and officers of the United States Navy, should have power plants that cost at least 2,400 dollars to 3,400 dollars per kilowatt made available to them so they are safe, does it really make much sense that their wives and kids back home should be living next door to power plants that cost only a couple of hundred dollars a kilowatt, and by virture of their costing only a couple of hundred dollars a kilowatt, they are nowhere near as safe?" And I answered that question that this wasn't really right. There are folks that will stand and give you long lectures as to how important it is that a military weapon system be reliable and so forth, and there have been many times in my life when I certainly believed that, but I also think that what goes on back home in peacetime is sort of important, too.

Now, as far as the differential cost of fuel is concerned, this one I just don't know. It is almost impossible to get numbers on what uranium fuel really costs. In fact, I guess the one statistic, the one that really scares me the most is that the last three hearings that I have been aware of in which nuclear power plants have been proposed -- you know the decision has already been made to build them -- the utility representative would walk to the front of the room and put a document on the table and say, "And here is our contract for nine year's worth of enriched uranium with Exxon Nuclear Fuels, Incorporated;" and you know, I just don't know how much longer we, as capitalists -- and we are capitalists -- should continue to fool ourselves about these things. We went through this 15 to 20 years ago when the utility engineers would walk to the Chairman of the Board and say, "Here is proof conclusive that we should abandon coal and go to residual oil burning power plants, and here is a seven year contract with Aramco for residual oil at, you know, too cheap to bother to meter." They were just going to throw it away, and look where we are today.

I would suggest that as adults we ought to really consider ourselves as intelligent capitalists. Because we are capitalists, we should simply face up to the fact that we are in a situation which, at Filene's Basement, they would call a loss leader situation. You get the customers in and you get them hooked, and then before you know it, why, they have had it and if a nuclear power plant and particularly if New England goes all nuclear as we are told to do now in the publicity, just about 10, 15 years from now, we will be absolutely and totally dependent upon the friendly vendors of enriched uranium.

How much do you think it is going to cost us? It is going to cost whatever the market will bear, and the market is going to bear one awful lot.

So, I just think that this promise of low cost nuclear fuel in the future is a total and complete phony.

As far as capital cost is concerned, the experience has been just unbelievable. You've got it right here in your back yard. In fact, if you have watched what happened in Yankee, Vermont, -- Yankee, Vermont, was accepted -- it almost had to be accepted by the State Government of Vermont because of some legislation that existed at that time. It was accepted on the basis that it would cost no more than 165 dollars per kilowatt, that it would generate electricity that would never cost more than four mils per kilowatt hour than it had thus far, and would do it for at least 30 years. When the power plant went on line, the power plant had cost well over 519 dollars per kilowatt and the electricity that's been coming out of there, because of the very low availability, is priced or is costed right there at over 20 mils per kilowatt hour, and the very same sort of thing, I believe, is happening to you at Shoreham. When the Shoreham plant was first proposed, it was going to cost something under 200 dollars per kilowatt and at the last look, it is well over 500 hundred dollars per kilowatt and, then, you have these next two, I understand, that are promised to you at some preposterous cost.

Now, if we are really, shall we say, prudent businessmen, their track record would point to the fact that we would take any estimate they give us and multiply by four. If you multiply them by about 1.05, they are already out of business in comparison with anything I am talking about.

There is another diseconomy which has become very apparent, which was not taken into account at all back in that 1968 period. Back in 1968, when it was decided to go to base load nuclear plus pumped hydrogen and in very large central units, at least 500 megawatts and then planning to go to a thousand and so forth. The assumption was made that the deliverability of those power plants would, indeed, be 93 per cent of the time, .93. Now, if you take the Federal Power Commission reserve requirements and you take a look at a total system, it is made up of so many base load plants, and so many intermediate plants and so many peaking power plants like, say, the one we went through last September was a 25,000 megawatt system. I guess it was twice as big as what we had in New England at the time, and you decide what that whole system should be made up of and then you say that the base load plants are going to be 1,100 megawatt nuclear plants. Then you do a parametric study and you say, "What's going to be required of us if the power plant does deliver electricity 93 per cent of the time?" And you come out with a number. "What if it gives it only 90 per cent of the time? What if it gives it only 85 per cent of the time, 80, 75 per cent and 70?"

This points out just a fantastic diseconomy of scale. The fewer of these great big things you think you can get along without, the more you are kidding yourselves because the bigger they are, the sensitivity and lack of deliverability is almost catastrophic. In fact, at the Millstone Hearings, Northeast Utilities was saying -- and this, by the way, not too many people paid too much attention to -- if they got 75 per cent availability from that next 1,300 megawatt power plant in 1982, then the generating costs projected at about 19 mils per kilowatt hour; but if you took those -- and they were going to build all kinds of these 1,000 or 1,300 megawatt power plants -- and matched them up with all of those that are required to give you 15 per cent reserve gotten usually from the gas turbine and so on and so forth, and then you take a look at what the average cost per kilowatt hour coming out of that thing is going to be, why, our average showed it was 29 million kilowatts per hour. We are talking about five cent electricity within a few years, ladies and gentlemen, unless we get on with some of these other processes; and anybody who tells you differently, he hasn't done his homework, as they like to tell me.

Things are changing very, very rapidly. So, you add all of this stuff up and just from an economic point of view, I can no longer see investing our capital in these power plants, and you know, capital is something we, also, have to pay more attention to. In the last few years, over 50 per cent of our new capital in this entire country has been required for the electric utility industry alone. Do you realize that? How much new capital are we generating this year to date in 1974? We have generated zero dollars of new capital. Our economy isn't what a lot of us think it is, and if we have less and less new capital with which to make these investments, we had better damned well be sure we spend our penny correctly because, 20 years ago we were in a nation that could spend the penny twice. We aren't going to be able to in the future.

The second biggest problem in the reactor program is economic scale. I happen to believe this, a lot of people don't. It is just the fact that it is a sodium cooled reactor. The economics of this thing are quite frightening.

Does that give you any idea as to what I think on nuclear power? I think it is a very poor choice, a very poor choice; and I think it is clear to me, at least -- and there are a lot of other people -- that we ought to get on with these alternatives and we ought to get on with them right now, and if we had the will to do it, why, we could have them in the very, very near future.

QUESTION: When would the solar system that you are proposing in the ocean be useable, and what would the capital cost investment approximately be?

HERONEMUS: I have said that with a properly organized and managed program, it would probably have to be Federally funded, -- and I have misgivings about this -- I am a card carrying Republican, believe it or not. I am one of the most conservative men on the face of the earth, but we have set the example that only the Federal Government can develop energy sources in this country. So, I just don't see industry stepping in and doing this -- with a properly organized and properly funded program, something like we used to build the Polaris missile system in the United States Navy, at the end of six years we could have the first of those 400 megawatt plants on site delivering electricity to Miami. That's a fast moving program, and if we had a thousand dollars per kilowatt available, that's a total of 400 million dollars, you could probably carry the cost of development as well as acquisition for the first power plant.

The second power plant, I think, is going to cost something very close to 600 dollars per kilowatt in 1974 dollars. I have to put one caveat on that, and that has to do with the cost of copper. We would dearly love to use copper nickel for those evaporators. If the cost of copper keeps going the way it has been going in the last six months, why, I have no idea what that thing would cost.

QUESTION: I would like to ask a question, Professor. Will offshore drilling on Georges Banks affect your good project? We are all for you and want to back your ideas. Could you tell us how we can help you to get your ideas implemented?

HERONEMUS: I would like to see us invest our capital in the offshore wind system instead of developing that gas and oil field for two reasons. First, I am sure we would make out better economically. Second, I also have a hang-up on burning gas and oil. I guess I am kind of soft-headed, but that stuff is so precious that, as we saw in the movie and so forth, we just can't keep on this way too much longer. We have to wean ourselves away from that, and if we stayed away from George's Bank and let a few more automobiles run out of gasoline, maybe we can get where we need to be faster.

As far as backing is concerned, probably the best way of trying to back some of these ideas is to contact Senators and Congressmen and tell them that you are absolutely convinced that we have got to do more about really developing these solar energy alternatives. That this idea of making research and development programs out of them for 30 years is okay, but let's get on with it.

Then, the next statement should be, "Please read the bills that are before the Senate and House right now and pick out the two that you think are the best and, then, talk with the others and get them passed."

One of the things that's happened in the last six months is that, strangely enough, we go from only one man in the entire Congress who knew how to sell solar energy to where we have 65 who want to sponsor solar energy bills, and there are some members of the political science discipline present, and I don't want to disparage them at all, but sometimes it seems as though it is as important to them to be associated with something worthwhile as it is to have something worthwhile happening. That's all right, but the competition in the Congress has now become ludicrous. In fact, they changed the name of the bill as they moved it from committee to committee.

We had a Mike McCormack Bill a few months ago. Fifteen million dollars just like that to demonstrate solar heating and cooling. Now, it's called the Moser Bill, and it is in Senator Gaylord Nelson's Committee; and I imagine one of the best ways for it getting out of that committee is for it to suddenly appear as the Nelson Bill. I don't know. I am being just a little cynical.

About all you can do is to put the maximum amount of leverage on those guys.

The way to do that is to suggest you can organize several hundred people one way or the other. Let's see some action.

QUESTION: If and when we do develop these offshore generators, how do we get the energy to the home without good old middleman being in there collecting?

HERONEMUS: You are going to have to have good old middleman. Whether he be private enterprise or socialized enterprise, somebody has to install and operate that system. You are going to have to pay an honest dollar. We don't do anything other than pay people for investing their capital. I have been thinking about public power authorities. You have one here in New York. What good it does you is open to debate, I guess. We talked about public power authority a little bit in Massachusetts. Some people think it would mean cheap power. I am afraid that doesn't necessarily follow. I think that one thing it would mean -- I am all in favor of it -- is competition.

QUESTION: Would you care to comment at all on the feasibility of using the temperature differential between the various levels of the earth?

HERONEMUS: I can comment very little. I have not studied this much. I am convinced in Colorado and California, Idaho and Nevada, you could do it very well. I say this because of the Rand Corporation Study. They are a pretty competent group and they concluded that.

Geothermal energy has a lot of potential. It is, also, heat that's released to the surface of the earth much faster than nature intended it. So, you have to pay some attention to the environmental impact.

QUESTION: In relation to solar energy, are there problems if you establish a shadow where there wasn't one before? Are you satisfied with the compatibility of side effects on the environment?

HERONEMUS: I have satisfied myself on the basis of preliminary studies. Also, the environmental impact of large scale uses of wind power is something that certainly should be studied. The reason I have satisfied myself preliminarily, though, goes something like this. Whenever you are dealing with solar energy, you are indeed entering an invariant heat system. There is no way in which you can change that which comes in. You can change the amount that's reflected. You can do that by painting over 10 per cent of the surface of the United States. It doesn't seem to have had any great impact.

Wherever we are going to shade the desert, somebody should certainly look at this. There are those that see nothing but good coming of it. I don't know. As far as the wind power is concerned, I have seen fit to start conversations with people competent in this field, and they have told me that I just couldn't put up enough wind generators in any one region to really affect the weather. Even I couldn't do this.

Now, I have some pretty big ideas as to how high up in the air I want to go. As far as the thermal energy, we really don't understand the mechanism as well as we need to. There are those that insist that the Gulf Stream is going to be cooled, and there are those that insist the Gulf Stream is going to be warmed.

If I can start that kind of an argument, then I say I can come right down the middle.

FEDERAL ENERGY LEGISLATION

Richard Hall, Esq.
Natural Resources Defense Council

Admiral Stephan, ladies and gentlemen, if anybody stands up before you and says they have a clear picture at any one time of the Federal Legislation attempting to affect energy, it is not me.

I would tend to disbelieve them. The situation seems to change daily. As Professor Heronemus put it, bills come and go. They change, they bend, people talk about trade-offs and everybody has a pet project.

Natural Resources Defense Council (NRDC) as such, has focused on several aspects of energy legislation. So, it is only when we touch upon those that I think I can talk in a great deal of depth. I think it is, also, critical, not only here, but in Congress that Federal Energy Legislation be seen not only as a lawyer's role to put down something on paper, but as something which affects the real choices that Professor Heronemus has talked about. So, part of the legislation that I will be discussing, will affect these critical choices. Some of it is attempting to create a government structure in which these choices can be made rationally and correctly, but creating a structure and making laws rationally and correctly are two very different things, and I don't think that they should be confused.

Now, in preparation for speaking to you, I wrote to a friend of mine, the Director of the Office of Energy Conservation, which is one division of the former Federal Energy Office and present Federal Energy Administration, and asked him for a list of the legislation which his office of the F.E.O. then and now F.E.A. was concerned with, and he came up with a list of 17 bills.

I will try to organize these bills to some extent, and discuss them in perspective.

I will take four major pieces of legislation. One is the Energy Emergency Act which started up with a great deal of ballyhoo last fall, was finally passed by both Houses of Congress and was vetoed by the President. The bill went back to both Houses; one version was passed in the Senate, while a different version has recently been passed in the House and they are about to go into conference. That was the bill, if you recall, that was going to come out of Congress to solve last winter's energy crisis. It was a little late. The winter is gone and we are told the crisis is gone too.

In an effort to structure the government's energy activity, the administration proposed that a Department of Natural Resources be created. When the so-called energy crisis heated up, that Department of Natural Resources was expanded and called the Department of Energy and Natural Resources (DENR).

Now, while that master plan was slowly fermenting on Capitol Hill, the administration went ahead and created the Federal Administration Office which you are familiar with; Mr. Simon was formerly the head of it, and now the head is Mr. Sawhill. That department was to contain, among other things, a statutory successor of the Federal Energy Office which was created by the Executive Order. That statutory successor of the Federal Energy Office is the Federal Energy Administration. So, the F.E.O. has now gone and we have the F.E.A., but it is the same thing.

In addition to the F.E.A., within the Department of Energy and Natural Resources, there is to be a special branch which will assume the research and development responsibilities of all of the existing agencies that have some energy impact, and it will undertake and receive the charge to conduct energy research and development as it is assigned under the administration.

So, on the one level you have an attempt to restructure existing and frequently diffused energy responsibilities into something more compact. And a man at the cabinet level at the top, I am quite sure, will be able to accomplish the so-called national energy policy.

Now, let me read to you what William Simon, in March of 1974, listed as the main components of the proposed Department of Energy and Natural Resources (DENR). He said it would incorporate most of the responsibilities of the Department of Interior, the activities of the Forest Service and certain water resource functions of the Department of Agriculture, the activities of the National Oceanic and Atmospheric Administration of the Department of Commerce, the water resource planning functions of the Corps of Engineers, the gas pipeline safety functions of the Department of Transportation and the Water Resources Council.

I think that by getting a sense of the variety and origin of the functions which will be taken over by this DENR, you get a sense of what is happening on Capitol Hill.

Much of the Congress is essentially organized around little feifdoms and jurisdictions, existing agencies, and when you start shifting agencies around, you start affecting Congressmen's bailiwicks.

If you find, for instance, that you come hard up against the Joint Atomic Energy Committee - and they are, in general, very influential people and they have a kind of a sweetheart relationship with the Atomic Energy Commission, with many of its research and development proposals, and powers - you find that in the attempt to resolve the energy problems by following a new course, you are once again mired in personal power struggles.

The one piece of legislation that has, perhaps, had the most discussion and the one that has had the most effort is the Energy Emergency Act. The history of that Act is constructive, and the confusion about it has resulted from the poor planning and policy that has been the practice in Congress. Essentially, that bill had two titles. The first title dealt, primarily, with rationing and energy conservation. The second title was essentially an effort to repeal or very substantially delay environmental controls which had some impact on the production of energy or the efficient use of energy. It is said that by the year 1985 or until then, under their present conception, energy conservation is going to be a more important aspect in making sure that the supply and the demand curves come closer to coinciding than is new production. Although the Senate passed both the conservation title and the title which would basically weaken environmental controls, the House of Representatives did not pass Title One of the Energy Emergency Act because they called it controversial. They turned around and only passed Title Two, which weakens environmental controls.

So, while conservation is being talked about, nothing much is being done about it in the halls of Congress.

Title Two, essentially, does three things. It amends the Clean Air Act by encouraging many plants to convert from oil to coal. It extends its deadline for meeting primary air quality standards, so that this conversion from oil to coal can take place as fast as possible. Also, the installation of scrubbers and precipitators for dirty coal, which is basically what they are talking about, will not have to be installed for five years.

Secondly, Title Two prevents the EPA from enforcing their transportation plans which they had adopted and were promulgating, pursuant to their obligation under the Clean Air Act. Under the Clean Air Act, it is necessary in urban areas to reduce the discharge of pollutants from non-stationary sources by other than catalytic converters or cleaning up engines. In some instances, there will be so many engines, basically automobile engines, that you will have to go beyond cleaning up the individual engines and reduce the amount of miles traveled in the urban areas.

Although coal is probably in shorter supply than oil because utilities will probably have a harder time getting coal than oil, Congress said, "Let's just delay the implementation of the Clean Air Act, despite the fact that the use of transportation plans will achieve some energy conservation, and will also cut down the amount of car miles traveled and thereby help in energy emergencies." Because they perceive that it would be difficult politically to impose upon the automobile society, Congress will direct the EPA not to enforce their transportation plan.

Lastly, Title Two of the Emergency Energy Act would basically delay for two years the 1976 automobile emission standards.

Now, the first two, - the conversion to coal with the delay of the clean air standards, and the prevention of implementing any new transportation plans - are unjustified from any realistic energy conservation viewpoint.

The third, the slight delay of the automobile emission standards is not, in view of the NRDC, a major problem.

Senator Jackson would like to see the Department of Energy and Natural Resources created before ERDA is created (Energy Research and Development Administration). The administration would like to see ERDA grow first, being the longer process, as they see it, of creating DEMR.

I don't think that anybody has any feeling that these kinds of decisions make any difference. I think you are basically talking about private bailiwicks, and that none of these decisions, per se, are terribly relevant to the energy picture. The political thing to understand is that Congress is rather mired in a multiplicity of bills; it is fighting about who has what jurisdiction, and it is not essentially playing any substantial role in the energy legislation picture.

Now, there are a number of other energy or so-called energy bills. I will touch upon them briefly.

One of the critical ones in Congress now is the strip mining reclamation law. Many utilities all around the country are cooperating with the coal industry and presenting the picture that the passage of the Senate or the original House Subcommittee Bill on regular surface mining will basically prevent the supply of coal from increasing substantially. In our opinion, this is just nonsense. That's without even facing the question that Doctor Heronemus raised, "Do we want, even under the best of reclamation circumstances, to have the kind of surface mining that's projected in the west and, to some extent, in the Appalachians?"

Oil shale, although that's not a legislative problem -- oil shale and off-shore drilling are, as you well know, proceeding apace in the administrative framework, but I think it is important to see that even Congress, certainly the Administration, is basically focusing on the supply side; very little is being done on the energy conservation side.

The kinds of choices that are really important for energy conservation need leadership and legislation to implement them forcefully.

Every type of supply, perhaps with the exception of solar energy, has all of the environmental and economic problems that Professor Heronemus has so eloquently mentioned. I think it is crucial that the energy conservation side be focused on much more strenously by Congress and by the Executive. In fact, energy conservation in the short term can play a very substantial role by insuring that the demand and the supply curves are pretty much in touch with each other.

DISCUSSION

QUESTION: Would you say that, summing it all up, our Congress is suffering from chickenpox? Would you say that Daddy Warbucks is still pulling the strings and, therefore, will not let any string loose so we can get something done?

MR. HALL: I really don't know what the cause is. I think the causes differ with different congressmen, but the end result is that nothing is coming out.

I think you will find Senator Jackson puts out an image that he is not afraid of the oil industry, and I don't believe that he is particularly, and he is one of the principal powers. Congressman Holofield, a critical power in the atomic energy field and the ex-Chairman of the Joint Committee -- I don't know who is calling all of his shots -- but I think there are conflicting forces which lead to an essential stalemate.

QUESTION: What do you feel about our energy budget? If 65 per cent of our budget is going towards nuclear power and two or three per cent towards solar, do you seriously think that solar will ever be funded or get an extension while this exists? Doesn't this imply there are political influences?

MR. HALL: That's what I am talking about in terms of the essential bailiwick of the existing Congress. Certainly, you can create an ERDA, Energy Research and Development Administration, which is a rational structure for dealing with the problem, and put the power to suggest R & D developments with them, and the House is in charge of funding; and if you have the same people making the R & D choices, pressing one R & D choice versus another and seeking funding, you are going to have the same reliance on the curve that was projected on the screen by Professor Heronemus.

Congress is half of the solution and half of the problem.

I don't really see leadership in Congress at this time to really grapple with these problems unless there is constant pressure from, if you will, the grass roots.

I don't think a specific legislative proposal to press solar or to press another energy source is likely to have much success. Everybody has their own pet project that they are or they are not pushing. I think, once again, you are going to have Congress creating a structure, creating an ERDA and DENR and, basically, asking the Executive to administer it.

I think that the answer is more likely to be a better Executive, a better informed Congress to pressure the Executive, people pressuring the Executive, and a general perception that the kinds of courses we are now on are suicidal, rather than a specific legislative solution to the problem.

Acceptance of the budget which is, in fact, legislation, involves the opening wedges, especially at the R & D level or at the level you are putting development money. I think they ought to take money out of the reactors, slow that down, if not kill it, and pursue other courses. The money involved would be substantially less.

They could fund three times what Prof. Heronemus is talking about, but those kinds of choices are not what most of the legislation is presently up to, excepting certain key congressmen who are wedged to key programs and certain committees; for instance, the Atomic Energy Commission, stands guard over existing choices.

QUESTION: Is there any legislative proposal to stop offshore drilling?

MR. HALL: I don't know of any, but I have not followed this issue. There may well be. Congressman Wolff may have something to say.

MR. MILLER: There are six bills pending right now. Senator Javits is sponsoring one of them. All six bills call for drilling and for greater safety measures and technological warranties, and a tougher environmental structure than now exists. Senator Jackson is also sponsoring a bill.

SUMMARY

Ann Carl
Regional Marine Resources Council

We have heard so many new things today that I hope we don't simply "wrap it up" and put it away. We have heard a lot of new ways of thinking about things, and that is what is encouraging.

We have come away with a hopeful point of view, where we had for a long time only been talking in terms of an energy crisis. Now we find there is a solution, if we begin thinking along new lines. Instead of accepting the inevitability of scarce and high-priced fuels and more environmental degradation, we can learn to effectively conserve energy, both in the public and private sectors, and we can turn to nonpolluting energy sources that are practical and available right now.

Our first speaker, County Executive John Klein, told us that Suffolk County has started an energy conservation program, and how it has begun reorganizing County functions to reduce energy needs.

Mr. Arthur Kunz, of the Regional Planning Board, gave a perceptive analysis of ways to plan land use so that transportation needs can be cut down, and, for the most part, supplied through various forms of mass transit. He particularly pointed out the energy conservation gains in clustering industry along the Island's spine, with residential areas on both sides. In this way, people living in each residential area need only commute halfway across the island - thus cutting fuel needs. Not only does this represent the broad view, but it indicates that energy conservation practices are already being used by planners of the Regional Planning Board.

Mr. John Mockvciak has pointed out something that we needed to have brought to our attention. That is, that we have been using buildings in a very sloppy way, thinking that we have energy to burn forever, and that we have limitless natural resources. He has shown how careful analysis of existing buildings by engineers like those in the Energy Systems Group at Grumman Aerospace Corporation, can economize on fuel and electricity use. This does not require that we rebuild buildings or wait for some great new plan. We can institute these energy conservation measures in any existing building right now. The savings can be amazing -- Mr. Mockovciak gave figures like 50 percent less fuel, 50 percent less electricity. He also said that the public should realize that if it wants the country to go a new way, for example, to solar power energy sources, it is up to the public to let Congress know, and to see that it gets done. This is another thought we should take away from this meeting.

The presentation by Mr. Barber and Mr. Watson from the School of Architecture, Yale University, gave us an exciting new approach to think about. They showed us how the really modern architecture of the present, instead of being based on mere esoteric and eclectic rearrangement of forms as it has been for some time, will now evolve from the fundamental demands of resource conservation, self sufficiency and survival. Their final slide brought it all together in one dwelling -- solar panels, energy conservation construction details, and power from wind generators. Buildings like these are being built right now. Architecture has been given a new challenge which it is meeting with imagination.

Mr. Marc Messing, from the Environmental Policy Center in Washington, gave us a very interesting historical view of our waste of gasoline, and of the various ways we could have gone, but didn't choose to, in transportation vehicles. One new concept he presented to us was that of "net energy." Looking at what we put in, and what we get out, are we putting in more than we are getting out?

We must begin to ask these questions in all our energy uses.

The movie -- "Energy Conservation: Less is More" -- summed up what was said in the morning session. Its message was that we have been free spenders and free wheelers for a long time, and the time has come to question this path very carefully. There are ways in which we can cut down on our use of energy and cut use of fuels and save natural resources, without cutting back on our so-called standard of living.

In fact, there has been much disenchantment with our standard of living, with its emphasis on more and more things, with its ugliness and lack of planning. Perhaps we would even find that energy conservation would lead to a more satisfying standard of living, and that might be a goal in itself.

Mr. Ralph Caso, Nassau County Executive, has been thinking about the energy problems in Nassau County for a long time, and this was evident in his thoughtful presentation. He has a long range view as well as immediate programs. When we consider what Mr. Klein, Mr. Caso, Mr. Kunz, and Mr. D'Amato said today, we can feel quite encouraged about our bi-county legislators. I think we should encourage them and tell them we like what they are doing.

Mr. D'Amato, Hempstead Town Supervisor, gave a provocative presentation showing how we can solve two problems at once: the solid waste disposal problem (including the recycling of valuable metals) and the problem of providing electrical power.

I don't think people realize how much power can be produced from the trash collected in a town. It was also interesting that Hempstead proceeded on this project by way of competitive bids. Instead of an arbitrary choice, several different schemes were considered. This is another encouraging aspect to Long Island planning -- projects are being looked at from all angles.

In fact, this is another idea to take away from the Seminar, and act upon. There has been much arguement and hard feeling between municipalities over the solid waste question. Citizens have repeatedly voted down new landfill operations. Why not encourage other towns to turn to this double barrelled solution? Not only does it take care of the solid waste, it also recycles glass and metals, and produces a useful and salable residue - electricity - and as a bonus, brings in revenue to the town.

It is hard to evaluate the contribution of Professor William Heronemus, of the University of Massachusetts, today, because it seemed to me that he summed up everything that we have been saying or wanting to say, and then stretched our minds as well.

From the long-range view of what we want to do with the earth, the most encouraging point is that we can use some of these nonpolluting "gentle" methods of energy production right now. They aren't processes that require new intricate technology; in fact, they are basic, age-old human aids. By contrast, Dr. Alvin Weinberg, head of Oak Ridge National Laboratory, has described those who must guard the wastes from the nuclear industry for eons of time, as a special "priesthood" of a special technology.

It is indeed exciting to know how practical wind power and sea thermal differences power are. Again, it is up to us, as Mr. Mockovciak pointed out, to demand that we follow this new route and not keep to our old and foolish ways.

Mr. Richard Hall, of the Natural Resources Defense Council, has completely confused us. But it is not his fault. His subject is confusing. In short, as he so well put it, Congress is not trying to solve the problem of energy, actually, but is busy protecting its old schemes and loyalties. It is avoiding a truly overall view that really comes to grips with the problem. Most especially, it has failed to appropriate adequate funds for development of new energy sources that would include solar, fusion, geothermal, magnetohydrodynamics, and other energy sources. And it has failed to reorganize the energy administrative agencies adequately.

He showed that the only path open to us is to let our Congressmen know that we won't tolerate things as usual, that we are in a crisis situation as far as the earth is concerned, and that we want adequate appropriations and legislation to further the earth-saving energy sources.

We are very grateful that you all came today, and I hope that these new concepts in energy conservation methods and these new sources for nearly unlimited, gentle energy, described here today will act as a challenge to work toward a positive solution of the energy problems now facing us. And as Professor Heronemus has said, "Let's get on about it and get it done."

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Appendix - Excerpts from the Congressional Record.
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[Subpanel IX, Report on Solar Energy to Dr. Dixy Lee Ray, October, 1973]

SECTION 4--WIND ENERGY CONVERSION

I. SUBPROGRAM SUMMARY

A. Introduction

1. The research area is concerned with practical extraction of energy from the wind, primarily directed toward the generation of electricity on a large scale. The research area includes efforts on cost reduction of subsystems and components, research and data collection on wind characteristics, user requirements, legal, environmental, institutional and aesthetic issues, optimization of design concepts, and the testing of a series of systems of increasing size and performance.
2. The objective of the Wind Energy Conversion Program is to develop reliable and cost competitive wind energy conversion systems capable of rapid commercial expansion for appropriate regions to produce significant quantities of supplemental electrical power by the early 1980's with the potential for meeting base load electrical power requirements.

A characteristic of Wind Systems is that the cost of the energy produced is a function of site wind characteristics as well as the technological capability. Thus, a characteristic of the program is that there is no question of success versus failure per se, but rather an increasing competitiveness over wide regions as system performance is increased. Therefore, the basic problem being addressed is to reduce the cost of wind energy systems and to verify and demonstrate that reduction.

B. R&D Programs:

1. Description

a. The specific goal of the Accelerated/Orderly Program is, by 1979, to have in operation cost effective systems in the 10 MWe range, along with completed preliminary design and component development to allow the operation of 100 MWe or larger systems by 1981. The program contains four program elements: 1) the Program Development and Technology element includes system and user requirement studies, supporting and advanced research and development on components and sub-systems, micro and macro scale wind and site characterization and research on legal, environmental, aesthetic and applications issues; 2) the Small Scale Systems Element will develop and test a 100 KWe wind-generator in FY 75 to provide the initial experimental cost and performance information, to be followed by similar sized units for diverse site conditions and special applications; 3) the MWe Scale Systems Element will develop and test larger wind-generators (1 to 2 MWe size) to provide cost and performance information at a scale appropriate for eventual commercial use to be followed by operation of similar sized units for diverse site conditions, higher performance and special applications; and 4) the Large Multi-unit Scale Element will develop and demonstrate two economically viable 10 MWe systems of large wind-generators and complete the preliminary design of a 100 MWe system of large wind-generators.

b. The minimum Viable Program maintains the same sub-element structure, with a stretched schedule, a smaller supporting research element examining fewer component and subsystem alternatives and fewer test units. The specific goal for FY 79 is to have in test one 5-10 MWe multi-unit test systems.

c. A crash program has been considered but at the present time, insufficient recent experimental data and analyses exist to allow speed up to the accelerated program in FY 75-77. Upon completion of the initial tests of the first MWe scale unit and based upon its performance, a considerable speed up could be obtained at an expenditure of additional funds. At some risk, the 100 MW scale demonstrations could be moved up from FY 81 to FY 79; the merits of this option can be examined in FY 77.

2. Schedule and Budget:

	Accelerated	Minimum viable
1. 1st 100 kWe test............	Fiscal year 1975-	Fiscal year 1975.
2. 1st MWe scale test..........	Fiscal year 1976-	Fiscal year 1977.
3. 1st multiunit test..........	Fiscal year 1978-	Fiscal year 1979.
4. 2-10 MWe wind-generator systems.	Fiscal year 1979-	Fiscal year 1981.
5. 100 Mw viable...............	Fiscal year 1981-	Fiscal year 1985-86.
6. Fiscal year 1975 funding....	$8,500,000..........	$3,800,000.
7. Fiscal year 1976-79 funding.	$97,700,000........	$23,100,000.
8. Runout to demonstration.....	$150,000,000.......	$150,000,000.

Cost uncertainty rests on lack of system level experience to determine both configuration dependent initial costs and lifetime operating costs and because of presently inadequate wind data and prediction methodology. Additional uncertainty exists in the requirements for storage as a function of application.

C. Implementation:

1. The maximum possible energy that can be practically extracted from the wind in the U.S. has not been determined. However, the NSF/NASA Solar Energy Panel has identified areas of the U.S. which could be used to generate 1.5 x 10^{12} KW-HR/yr or nearly all the electric power presently generated in the U.S. If all these areas were utilized, approximately 18 percent of our estimated power generation of 8 x 10^{12} KW-HR/yr for the year 2000 could be supplied by wind energy systems. The actual implementation could be considerably larger or smaller than these estimates based on the results of actual performance achieved and detailed wind surveys.

2. Implementation of additional wind-energy systems after successful demonstrations should be relatively straightforward. Rapid expansion following the 1981-82 period can be expected from the accelerated program. The minimum-viable program will result in a slower implementation due to the larger time required to reach demonstration systems.

3. Possible barriers to implementation include:

a. unknown reaction of utility community due to unusual characteristics of wind-energy systems and limited lifetime proof from early test units

b. unknown public reaction to aesthetics

c. possible "wind rights" legal questions

d. effects on micro and macro climate are expected to be neglibible, but the degree of proof required is unknown at this time.

FIG. 12.-PROGRAM BUDGET SUMMARY

WIND ENERGY CONVERSION SUBPROGRAM, ACCELERATED ALTERNATIVE: FEDERAL OBLIGATIONS

[In millions of dollars]

Program element	1975	1976	1977	1978	1979	Total, 1975-79	1980-89
Program development and technology............	3.5	4.5	4.5	4.5	3.0	20.0	10
Small scale systems....	1.5	2.0	1.8	.8	.5	6.6	0
Megawatts electrical scale systems..........	3.0	9.1	10.0	5.6	2.1	29.8	0
Large scale multiunit..	.5	1.7	7.2	23.0	17.4	49.8	[1] 33.8
Total...............	8.5	17.3	23.5	33.9	23.0	106.2	43.8

[1]Through 1982.

FIG. 14.-PROGRAM BUDGET SUMMARY

WIND ENERGY CONVERSION SUBPROGRAM, MINIMUM VIABLE ALTERNATIVE: FEDERAL OBLIGATIONS

[In millions of dollars]

Program element	1975	1976	1977	1978	1979	Total, 1975-79	1980-89
Program development and technology............	0.8	1.1	1.2	1.1	0.8	5.0	15
Small scale system.....	1.5	2.0	1.8	.8	.5	6.6	....
Megawatts electrical scale system...........	1.0	1.5	2.6	1.5	1.4	8.0	20
Large multiunit systems[1]	.5	.8	1.5	3.5	1.0	7.3	88.1
Total..............	3.8	5.4	7.1	6.9	3.7	26.9	123.1

[1] 10 MWe system by 1981 and 100 MWe system by 1986.

II. STATUS OF THE TECHNOLOGY

A. Present Status:

1. In 1910, Denmark was generating 5 x 10^5 MWe--HR/year from wind systems with a total installed capacity of 200 MWe. From 1930 to 1960, considerable interest existed in Europe (and in the United States in the 1940's) in developing large, more modern, wind-driven, generating systems as a source of electrical power. These systems typically included a multi-bladed wind-turbine, an electrical generator and a control system, mounted on a tower. An energy storage system, usually pumped water or batteries, was sometimes included in the sytem. The test systems were rated from 100 Kw to 1250 Kw and provided power to both individual users as well as to existing power networks. However, interest in these test systems declined because they were not cost-competitive with fossil fuel plants of that era. These efforts were generally individually entrepreneured and suffered from the lack of a sustained R&D effort. Wind-generator technology has thus been arrested since the mid-1950's, and little of the technological development of the past two decades has been applied to wind-generator systems.

SECTION 5--BIOCONVERSION TO FUELS

I. SUBPROGRAM SUMMARY

A. Introduction:

1. Bioconversion comprises three areas: the conversion of organic wastes to energy, the production and utilization of biomass for energy, and the production of hydrogen by photosynthetic and other photochemical systems.

2. The objectives of the bioconversion program are to assess the available technology for producing and utilizing organic materials for energy, to develop new technology, and to establish the feasibility of the various processes through pilot plant and full-scale demonstration plants. The optimum program would be capable of utilizing organic wastes in the near term and subsequently biomass to produce synthetic fuels for heat for large scale utilization in lieu of fossil fuels. Ultimately, the program would provide means for the direct production of hydrogen as a significant source of energy.

B. R. & D. programs:

1. a. The accelerated orderly program will provide by 1980, (1) seven pilot plants of 1 ton/day capacity for converting urban solid wastes, animal wastes, and/or other organic materials to methane or higher hydrocarbons, (2) one demonstration plant of about 100 tons/day capacity for converting solid wastes to a useful fuel, (3) production of hydrogen by photosynthetic and biophotochemical methods, and (4) development of high yield crops which can be harvested for energy production.

b. In the minimum viable program the number of pilot plants would be reduced from seven to three; the demonstration plant would not be planned until the 1980's and all other accelerated research would be reduced.

c. Crash Program:

Two bioconversion projects lend themselves to crash development because of their advanced status. They are (1) anaerobic conversion through the utilization of

FIG. 16.-ENERGY R. & D. PROGRAM BUDGET SUMMARY

BIOCONVERSION SUBPROGRAM, ACCELERATED ORDERLY PROGRAM (ALTERNATIVE): FEDERAL OBLIGATIONS

[Dollars times 10^6]

Program element	1975	1976	1977	1978	1979	1980-89
1. Conversion including fermentation, chemical reduction, pyrolysis, and combustion:						
Research and technology	2.6	2.6	2.6	2.6	2.6	5
Engineering development	2.0	2.0	2.0	1.0	1.0	2
Pilot plants	2.0	4.0	6.0	5.0	3.0	4
Demonstration plants		1.0	3.0	10.0	19.0	4
Total	6.6	9.6	13.6	18.6	25.6	15
2. Organic material products:						
Research and technology	3.0	4.0	4.0	3.0	3.0	6
Engineering development	1.0	2.0	3.0	2.0	2.0	2
Pilot plants			1.0	2.5	2.0	2
Demonstration plants				1.5	3.0	20
Total	4.0	6.0	8.0	9.0	10.0	30
3. Biophotolysis:						
Research and technology	1.5	1.7	2.1	2.5	3.0	8
Engineering development					1.0	2
Total	1.5	1.7	2.1	2.5	5.0	10
Grand total	12.1	17.3	23.7	30.1	40.6	55

Note: 5-yr total equals $123,000,000

FIG. 17.-ENERGY R. & D. PROGRAM BUDGET SUMMARY

BIOCONVERSION SUBPROGRAM, MINIMUM VIABLE PROGRAM (ALTERNATIVE): FEDERAL OBLIGATIONS

[Dollar times 10^6]

Program element	1975	1976	1977	1978	1979	1980-89
1. Conversion including fermentation, chemical reduction, pyrolysis, and combustion:						
Research and technology	2.0	2.0	2.0	2.0	2.0	5.0
Engineering development	2.0	2.0	2.0	1.0	1.0	2.0
Pilot plant	2.0	3.0	1.5	1.5	1.5	1.5
Demonstration plants					1.0	33.0
2. Organic material products:						
Research and technology	1.0	1.5	2.0	2.0	1.0	5.0
Engineering development	.5	1.0	2.0	2.0	1.0	5.0
Pilot plant				1.0	2.0	4.5
Demonstration plants						20.0
3. Biophotolysis:						
Research and technology	1.0	1.0	1.0	1.0	2.0	8.0
Engineering development					1.0	2.0
Total	8.5	10.5	10.5	10.5	12.5	86.0

Note: 5-year total equals $52,500,000.

fermentation plants, and (2) urban solid waste conversion by pryolysis and/or incineration. Several, single unit, feedlot fermentation plants for 10,000 head and larger could be initiated in 1975. Each plant would yield approximately 10^5 SCF/day of methane. Similarly, demonstration plants capable of disposing of solid waste from urban communities of 100,000 population could be built in 1975 to process 200 tons/day of solid wastes. These latter plants would be expected to yield approximately 2×10^9 BTU/day in the form of heat, low BTU gas and/or oil.

C. Implementation:

1. Readily collectible wastes could provide methane equivalent to about six percent of the present natural gas use, or nearly two percent of present total U.S. energy consumption. Attaining goals in agriculture to produce raw materials might raise contributions to 10 percent of total energy.

2. Time Schedule: In the accelerated program for bioconversion it is considered that economic and technical feasibility are presently established. Pilot plants would be established during the period 1976-78, and one or more demonstration plants would be established during 1977-78. For biomass production, economic feasibility would be established during 1975-1977, and technical feasibility would be established during 1978-1979. Then pilot plants would be established during 1979-1980 followed by a demonstration plant during the early 1980's. For biophotolysis the goal is to establish economic and technical feasibility. No pilot or demonstration plants are planned before 1985.

In the minimum viable program for bioconversion the pilot plant is planned but would be developed over a 2-year longer period than in the accelerated program. The demonstration plant is not planned until some time after 1978. The biomass program would be carried out at a slower rate with technical feasibility not being completed until 1980. A pilot plant is not scheduled until after 1979 and no demonstration plant is planned. For biophotolysis, the plans for the minimum viable program are to establish economic and technical feasibility by 1980 or later.

3. Few barriers are anticipated because the proposed technology would make better use of our natural resources without readily visible ill effects.

SECTION 6--OCEAN THERMAL ENERGY CONVERSION

I. SUBPROGRAM SUMMARY

A. Introduction:

1. The oceans serve both to collect and store tremendous quantities of solar energy. By utilizing the natural temperature difference between the surface and deep ocean waters, a heat engine can be operated. Experiments by Claude have demonstrated the concept off Cuba, producing 22 Kw of electrical power. Studies indicate that significant amounts of energy (compared to total U.S. needs) can be economically harvested in this way from the ocean. Because the temperature difference (40° to 50° F) is small, the Carnot efficiency is about 5%. However, the available thermal energy is enormous. The process requires no fuel or fresh water and the associated power plant technology is straightforward, hence, the resulting electrical energy should be competitive in cost with that produced by present-day power plants.

2. This development program is intended to demonstrate the practical feasibility of converting ocean thermal energy into electricity. System reliability and economic

FIG. 20.-BUDGET SUMMARY:OCEAN THERMAL CONVERSION SUBPROGRAM-ACCELERATED ALTERNATIVE

[In millions of dollars]

	Fiscal Year									
	1974	1975	1976	1977	1978	1979	1980-84	1985-89	1975-79	1980-89
Engineering, ART,SRT		5.5	6.0	6.4	6.8	6.3	20.1	15.3	31.0	35.4
Design and construction of test facilities		3.0	7.0						10.0	
Component fabrication and testing			4.0	6.0					10.0	
Site selection		.1	.2			.2	.3		.5	.3
Pilot plant design and contracting			2.0	4.0	2.0				8.0	
Pilot plant construction					20.0	20.0			40.0	
Pilot plant testing							8.0			8.0
Demonstration plant design and construction							212.0			212.0
Demonstration plant testing							12.5	25.5		38.0
Total		8.6	19.2	16.4	28.8	26.5	252.9	40.8	99.5	293.7

FIG. 21.-BUDGET SUMMARY:OCEAN THERMAL CONVERSION SUBPROGRAM-MINIMUM ALTERNATIVE

[In millions of dollars]

	Fiscal Year									
	1974	1975	1976	1977	1978	1979	1980-84	1985-89	1975-79	1980-89
Engineering, ART,SRT		4.0	4.5	5.0	5.5	6.0	26.5	15.5	25.0	42.0
Design and construction of test facilities				2.5	4.5	3.0			10.0	
Component fabrication and testing					2.0	3.0			5.0	
Site Selection				.1	.2		.5		.3	.5
Pilot plant design and contracting						1.0	3.0		1.0	3.0
Pilot plant construction							10.0			10.0
Pilot plant testing							3.0	3.0		6.0
Demonstration plant design and construction								212.0		212.0
Demonstration plant testing								12.5		12.5
Totals		4.0	4.5	7.6	12.2	13.0	43.0	243.0	41.3	286.0

viability will be determined, along with an associated assessment of the technology and environmental impacts. The potential for production of protein and fresh water as valuable by-products will be investigated. Engineering problems to be solved include the development of deep-water pipes of large (order of 50 foot) diameter (along with methods for their deployment) and the design of appropriate heat exchangers and pumping systems. A selection must be made between an open or a closed thermodynamic cycle, and as to the transmission of energy from ocean locations to land. The legal questions associated with operations in international waters must also be examined.

B. R&D Programs:

1. a. Accelerated orderly program: This program looks toward an early 1980's demonstration of technological feasibility, so that the immense thermal energy resources of the oceans would soon begin to be taped. Advanced development and engineering will produce components and subsystems, overlapping and near-shore pilot plants and test facilities.

b. Minimum viable program: This program compromises on the above program by utilizing only a near-shore pilot plant/test facility in conjunction with the associated advanced development and engineering. The minimum viable (near-shore) program would not come to grips with many potential features associated with ocean-based operations. Consequently, feasibility determination and ultimate commercial implementation of ocean-thermal plants will be delayed several years.

c. Crash program: Because the basic technology for ocean-thermal plants exists today, the accelerated program is amenable to efficient conversion to a crash program. A crash program for this relatively low-level technology can be conducted at low technical risk and with high probability of successful completion within the time and funding allocated. The rate of advanced R&D would be doubled, and from two to four pilot plants constructed during the five-year period. A demonstration plant could be designed and constructed by the end of the decade, shortening the time to this milestone by almost three years.

The accelerated orderly program calls for the completion of construction of two 5-10 Mw pilot plants by FY 1980. One will be located near shore, and the other will be ocean based. The minimum viable program provides for only one near-shore pilot plant, to be completed by FY 1984. Both programs include a demonstration plant, and their respective schedules are shown in Section I.

C. 2. No major technical barriers are envisioned, but legal aspects of ocean-based plants may be a major problem.

C. Implementation:

1. Projected size of the applications after implementation: The solar energy impinging on the topical oceans averages 20 watts/ft^2 or 560,000 Kw/mi^2. Thus, for thermal equilibium at 3% net conversion efficiency, a 500 Mwe plant would extract the heat supplied by the sun to 30 square miles of ocean surface. Since more than 30 million square miles of ocean have appropriate thermal conditions, as many as one million plants--each of 500 Mw output--could conceivably be operated (having a total output of over one thousand times the current U.S. capacity for

electrical energy generation). The output of the ocean-thermal plants would be transmitted to the user as electricity and/or by conversion to an intermediate fuel such as hydrogen. Thus, several thousand such plants could supply all current U.S. energy requirements.

2. Time scale for implementation. (Not reproduced here.)

3. Possible barriers to implementation: The heat-exchanger and cold-water pipe designs represent possible technical problems, but are not expected to be barriers. Possible environmental impacts of large-scale implementation will require study. Possible institutional barriers to widespread implementation include lack of short-term private incentives and international legal questions.